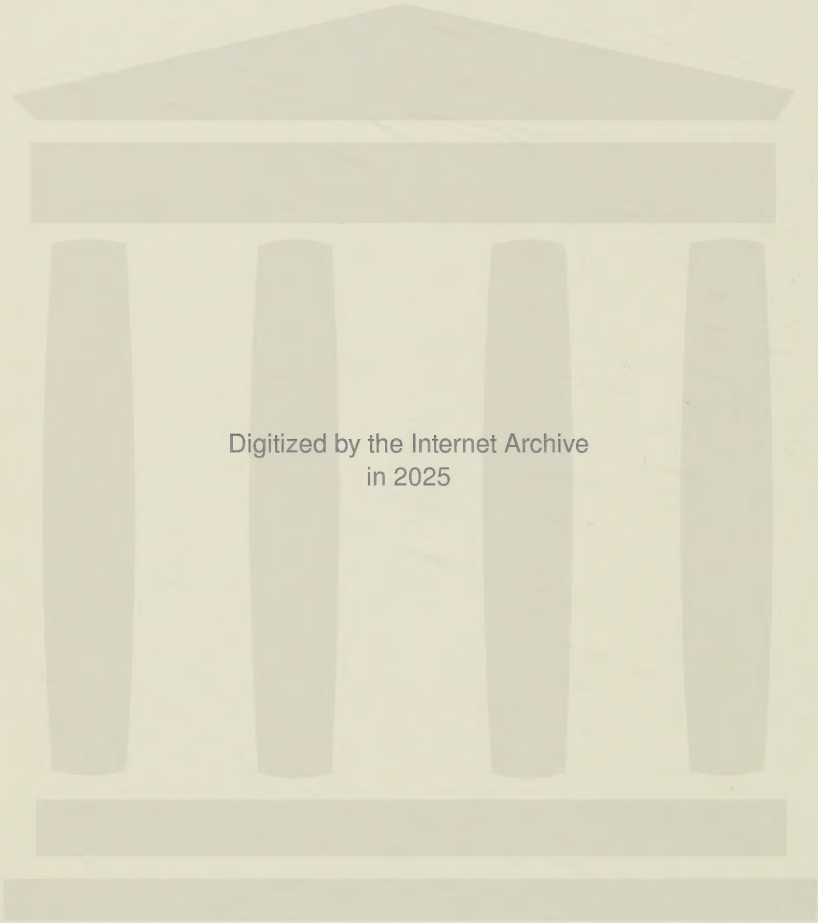

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6. REPORTS

1906-20

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90. 1918. Mycology and plant pathology. Rep. Bd scient. Advice India, 1916-17: 47-56.

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Part IV.

ANNUAL REPORT OF THE CRYPTOGAMIC BOTANIST TO THE GOVERNMENT OF INDIA FOR THE YEAR ENDING THE 30TH JUNE, 1905, WITH A BRIEF ACCOUNT OF THE WORK OF THE OFFICE OF CRYPTOGAMIC BOTANY OF THE DEPARTMENT OF AGRICULTURE SINCE ITS CREATION.

I. PREFATORY.

1. I joined the Department of Agriculture early in April 1902, and have held charge of the office of Cryptogamic Botany of the department since that time. A year previously was spent attached to the Botanical Survey of India in the Royal Botanic Gardens, Calcutta, but as the time was occupied in acquiring some knowledge of the conditions of mycological work in India and was not specially devoted to the agricultural aspect of the science, no reference to it will be contained in the following report.

2. The subject of Cryptogamic Botany includes all the non-seed-bearing plants, that is to say, the *Algæ*, *Fungi*, *Mosses* and *Ferns* and their allies. The chief group of agricultural importance is the fungi and my work has lain mostly with these plants, being such as is usually performed by a Mycologist. In a country of the size of India, with its differences of crops and climates, touring has naturally been of the utmost importance. By this means a knowledge has to be obtained of the principal diseases of crops induced by fungi. The information thus gained has to be worked out in the laboratory, life-histories studied and the general relations between host and parasite examined by laboratory methods. Field experiments under close observation are often required to complete the work and an experimental field of several acres was taken up for this purpose rather over a year ago.

3. The *fungus flora* of India has not been the object of many researches. Collections of fungi made by individuals have been sent to Europe for identification from time to time. The value of this may be gauged by the fact that on several occasions the same fungus sent to two different authorities has been differently determined. Two Mycologists have, however, actually worked in the country, Doctors Cunningham and Barclay, both medical officers in the employment of the

Government of India, and their work has been of the greatest value. Type collections, that is to say, specimens actually named by the authorities by whom they have been examined, are practically non-existent in the country. One of the first essentials is, therefore, to get together a herbarium of fungi collected in India and preserved for reference. Over a thousand specimens have been obtained and in part determined, and these are stored in the herbarium attached to the office. In addition nearly 900 specimens of parasitic fungi have been purchased from abroad for comparison with the indigenous species.

II. ESTABLISHMENT, TOURING AND GENERAL.

4. **Establishment.**—A clerk and two fieldmen were appointed in 1902-03. In 1903-04 two assistants were added and in the present year a third assistant and two more fieldmen. The difficulty of obtaining good men for the scientific posts has been sometimes acutely felt.

5. **Touring.**—I have travelled about 40,000 miles in India in the three years under review, 170 days were spent on tour in 1902-03, 127 in 1903-04 and 151 in 1904-05. The following are the principal tours which have been made and their general objects:—

1902-03.—I visited Coorg in July-August in connection with "spike" disease of sandal trees, Assam in August-September to study some tea diseases, and Bombay (Poona and Surat) in September-October for a preliminary examination of field crop diseases. A short time was spent in October at Nagpur in the investigation of the *tur* (*Cajanus indicus*) wilt disease. In November I visited Behar where a serious outbreak of sugarcane disease had occurred. Several weeks were spent at Cawnpore farm in the spring of 1903 working at cereal rusts, and Hissar in the Punjab was visited for the same purpose in February and April.

6. *1903-04.*—The Bombay government farms at Surat and Poona were visited in August and some experiments in the treatment of ground-nut and *tur* diseases conducted. After seeing the Government sugar station at Samalkot, and spending some days at the Government Botanist's office in Madras working through his collections of crop parasites, I toured in Mysore in September visiting some of the coffee districts and continuing the study of sandal spike disease. Several sugarcane diseases were investigated in Bengal in October and November. In January work was continued at Cawnpore on cereal rusts, and a visit was paid to Pusa in February to examine the sugarcane varieties there for disease at planting.

7. *1904-05.*—A short visit was made to Saharanpur early in August to inspect the fruit trees in the Government gardens in order to decide on the freedom from disease of the grafts and seedlings required for the new fruit garden at Pusa. I spent some days at the Royal Botanic Gardens, Calcutta, in the same month, in the identification of specimens, and have to acknowledge my indebtedness to the staff both on this and on several other occasions for much assistance received. I subsequently investigated a fungus disease of the casuarina plantations at Chatrapur in the Ganjam district of Madras. In September I toured in Mysore in connection with the investigation of spike disease of sandal trees, and in the Coimbatore district of Madras for a preliminary examination of field crop diseases. Pepper vine disease in Malabar and Wynaad and tea and coffee diseases in the Droog range of the Nilgiris occupied most of October, and in the same month I also studied a disease of prickly pear in the Trichinopoli district which the Forest Department hoped might serve as an effective check to the extension of this troublesome plant. Three visits were made to Pusa, in January, February and April, in connection with the Board of Agriculture meeting, sugarcane diseases and the discussion of work connected with the institution with the Inspector General of Agriculture and the other members of the staff; and two to Calcutta, in January and May, in connection with the proposed publications of the department and other departmental matters. A preliminary investigation of some plant diseases in Assam was made in May and June, Shillong, Wajhain and several places in Sylhet having been visited.

8. Munshi Inayat Khan, fieldman, collected specimens in the United Provinces, the Central Provinces and Berars, Central India, Rajputana and the Mussoorie and Simla hills, in the spring of 1904, all primarily in connection with cereal rusts. He also visited Saharanpur in March 1905 in a search for disease-free sugarcane varieties. Mr. Mitra, third assistant, visited Lyallpur, Punjab, in March 1905 to make notes on an outbreak of wheat rust there. Mr. Basu, first assistant, worked in the Government Botanist's office, Madras, in May, 1905, chiefly in carrying out inoculations of pepper-vines with the pepper *Nectria* but was obliged to leave through ill-health before the work was completed.

9. **Provincial work in fungus diseases.**—It is satisfactory to record an increasing interest in the study of fungus diseases of plants in several provinces during the past few years. In Madras, the government farms at Samalkota (sugarcane), South Arcot (groundnut, etc.), and Taliperamba, Malabar (pepper), the last two of which

have been started during the past year, are carrying out investigations in the diseases of these plants under the direction of the Government Botanist. The South Mysore Planters' Association has also determined this year to start an experimental garden, where the study of the behaviour of different varieties of coffee to disease will probably be one of the lines of work. In Bombay some experiments in the direction of finding varieties of *tur* resistant to the wilt disease are in progress at the Kirkee farm, and some work has also been done with the ground-nut disease. At Cawnpore the study of cereal rusts has been taken up by the Deputy Director of Agriculture, United Provinces, and a paper has been prepared in conjunction with myself detailing the results of our work up to 1904, to which has been added a note on the relations of the weather to rust in wheat by Mr. Moreland. The Board of Agriculture has recommended (Proceedings of meeting of January, 1905, paragraph 6) the commencement of work with a view to obtaining varieties of wheat resistant to this disease at a locality in the Punjab and at Hoshangabad in the Central Provinces. The treatment of smut on *juar* and wheat has been found successful at the Nagpur farm and the practice introduced to the cultivators. At Shillong experiments in spraying for potato blight have given a measure of success recorded in the last year's Report of the Department of Agriculture, Assam. A considerable correspondence has arisen in connection with these experiments and as a consequence of frequent enquiries from superintendents of farms, etc., regarding fungus diseases.

10. **Epidemics of fungus diseases.**—Plants are subject in the same measure as animals and man to outbreaks of epidemic disease. Several of these have come to my notice since I arrived in India. Potato blight, for instance, was first noticed in Lower Bengal in 1900 and reached epidemic violence in 1902. It had not previously been known in the plains, though frequently severe in the hills of various parts of India. The mysterious disease of sandal known as "spike" first received detailed mention in a Memorandum by the Deputy Conservator of Forests, Coorg, in 1899. Since then it has rapidly extended, a large part of the Mysore and some of the Madras sandal areas being now infected. The betel palm plague in Sylhet, first reported this year, has only been noticed within the past few years but has destroyed fifteen-sixteenths of the palms in some gardens visited. A mildew on tobacco, recently discovered, threatens an epidemic in Bengal, but has so far been reported from one district only. The

palmyra palm disease in the Godavery delta, apparently of recent origin, appears to have acquired an epidemic frequency this year. The coffee twig disease in the Nilgiris and Neliampatties investigated last year is stated to have appeared about three years ago. It has already done much damage in the infected districts. Of a somewhat different order are the cereal rusts and red-rot of sugarcane which are endemic but have their periods of maximum and minimum intensity. Of the natural laws governing these we have at least some indication. In the case of rusts climatic conditions are apparently all important, while the red-rot of sugarcane probably increases with the increasing number of diseased canes planted, and receives a check when a variety becomes so diseased as to oblige the cultivators to replace it with a less infected kind. The climatic influences in their relation to rust received an illustration last year, when conditions in the earlier part of the season being favourable, rust appeared extremely early. There was every indication of a bad attack resulting, but the disease seemed to receive a check from the great cold experienced this year in Northern India and a general outbreak was averted; though in parts of the United Provinces, in Behar and in Jubbulpore, where the conditions were less unfavourable, severe damage was caused.

11. **Treatment of fungus disease.**—The direct destruction of fungus parasites, in the way that insect pests are dealt with, is often impracticable with the means at present at our disposal. These minute parasitic plants usually occupy the interior of the tissues and cannot be reached by the substances employed without damage to the latter. But their reproductive bodies or spores are ordinarily formed on the surface and set free into the air or soil, and the extension or germination of these may sometimes be prevented. For this purpose spraying with fungicides or removal and burning of diseased parts are employed. But spraying, which is in its infancy even amongst the more highly educated farmers of Europe, is not likely to be adopted generally by the ryots in India for some time to come. And indeed the number of diseases that I have seen in India which are likely to repay spraying is small. Of the ordinary field-crop diseases, potato blight and ground-nut leaf-spot are the chief, and even in these reliable results from experiments in India are not yet available. No special attempts have, therefore, been made to introduce spraying into practice. The other method of preventing spore dissemination, the destruction of diseased parts, is capable of wide application in a number of cases, and this practice has several times been explained and recommended. A group of diseases, chiefly

those known as smuts, is conveyed on the seed. Disinfection here is often comparatively easy and cases of its practical application will be mentioned below. Another group of diseases, chief of which are potato blight and probably sugarcane red-rot, is transmitted by the use of internally affected seed, and the supply of healthy seed is the first requisite in these cases. But for many diseases, for cereal rusts, coffee leaf-disease, *tur* and pepper wilts, etc., the breeding of resistant varieties offers the chief hope of eventual success. I look forward to the time when private seedsmen or Government departments of agriculture will make the supply of resistant varieties and of disease-free seed one of their important lines of work.

III. INVESTIGATIONS OF CROP DISEASES.

12. **Potato diseases.**—An enquiry was made in 1902 into the diseases affecting potatoes, their prevalence and distribution. Potato blight caused by *Phytophthora infestans* was found generally present in the hills, being prevalent in the Himalayas from Bhutan on the east to beyond Simla on the west, in the Khasia hills and in the Nilgiris. In the plains it is less common being obtained from Bengal only. "*Bangdi*" blight, characterised by blackening of the stems and tubers, is a serious disease in Bombay. It is allied to those potato diseases in other countries which have been ascribed to bacterial action. Other diseases of minor importance occur in various localities. An account of the history of these diseases, their causes, and the remedies suggested was published in the Agricultural Ledger series in 1903.

13. **Wheat rusts.**—The study of these, probably the most serious of any crop diseases of India, was commenced in 1903, and has continued each season. The species of rust fungi concerned, their life-history in relation to other plants and the behaviour of different varieties of wheat to their attacks required investigation, practically nothing being known on these points. Much of the work was done in conjunction with Mr. Hayman, Deputy Director of Agriculture, United Provinces, at the Cawnpore farm. A first paper was published in 1903, and a second, in collaboration with Mr. Hayman, has been in the printers' hands for many months, a delay having occurred in printing the plates. Three varieties of rust have been found, the black rust caused by *Puccinia graminis*, the yellow rust caused by *P. glumarum* and the orange rust caused by *P. triticina*. All three are known in Europe. Their distribution has been in part investigated, and search made for other plants on which a

part of the stages in the life-history may be passed. The æcidial stage of black rust, described by Barclay on Simla barberries, has not been found in the hills further east, nor in the Nilgiris. The barberry rusts of these localities are unconnected with wheat rust. This rust, too, was in 1904 the prevalent rust in the central parts of the country, at distances from the habitat of the barberry so great that it is impossible to suppose any connection to have existed. Yellow rust has been found on two grasses, *Phalaris minor* and *Brachypodium sylvaticum*, and Barclay mentions that black rust occurs on a grass, probably *Brachypodium distachyum*, at Simla. But the rusts on the first and third of these do not readily pass to cereals. No other host has been found bearing any of the three rusts, the one remaining likely "intermediate host" *Launea asplenifolia*, the *Æcidium* of which was described by Drs. Cunningham and Prain in 1896, and considered to be possibly connected with orange rust, having been shown experimentally to have no relationship. The conclusion has been arrived at, therefore, that the influence of other plants on the disease need not be taken into consideration. The means by which the disease persists from one wheat season to another are still unknown, the indications being that spore infection from the spores of the previous year's crop will not account for it. The alternative hypothesis put forward by Professor Eriksson of Sweden that disease germs are conveyed in the seed in the form of a protoplasm mingled with that of the wheat plant, has received no experimental support from our work, though it offers a more comprehensible explanation than any other. The experiments are still in progress and consist mainly in growing a few plants of wheat each year in germ-tight cases to determine if any of them will develop rust under conditions which prevent outside infection. The specialisation of the races of the parasite on wheat, barley, etc., *i.e.*, the degree to which the form on each species of host is confined to that host, was investigated. Both the black and yellow rusts of wheat were found capable of passing to barley in some cases. Attempts to produce the yellow rust of wheat from barley failed. Orange rust could not be inoculated on barley, and none of the three on oats. The specialisation of the yellow rust differs to some extent from that observed in Europe. Enquiries made in the Punjab and elsewhere indicate that rust is induced by cloudy moist weather at the season of rust prevalence. This is in harmony with the meteorological observations analysed by Mr. Moreland in their relation to rust in some selected districts of the United Provinces.

14. The chief experiments carried out in 1904-05 were the following. An attempt was made to determine if the first outbreak of rust would be in any way affected by submitting the seed to various degrees of heat before sowing. On Professor Eriksson's theory it was thought possible that a difference of a week or two might be apparent between the first cases in the treated and untreated plots, for it is possible that if any internal germ exist it may be destroyed by heating. In experiments on seed treatment against rust previously carried out in other countries no distinction has been made between the first outbreak, which is usually slight, and the secondary spread caused by spores from the first attacked plants. Yet it is certain that the two sets of cases have a different origin, for the earlier cases can only arise from infection carried over in some way not yet understood from the previous year's crop. Nothing was observed, however, which would lead one to hope that seed treatment by heat will affect even the first cases. An experiment was also made to determine the degree to which the susceptibility of a wheat to yellow rust is dependent on its liability to infection by uredospores produced on the first attacked plants. A tent of cloth sufficient to arrest the passage of air-borne spores was erected over a small plot before rust appeared. On opening, some weeks after the first outbreak, the marginal plants which were exposed to infection carried in by insects at the ground level were found considerably rusted, while those in the centre largely escaped; 160 rusted leaves being obtained from the marginal 78 square feet and only 24 in the internal 112 square feet. Hence in this case susceptibility evidently depended on the liability to secondary uredospore infection. Several determinations of the thermal death-point of the uredospores of yellow rust were made in February and March. Moist heat between 45° and 50° C. for five minutes was found to destroy the power of germination.

15. **Other rusts.**—Over 70 species of *Uredineæ* parasitic on different plants have been identified. Several of these are serious parasites of cultivated crops. Amongst the more important are *juar* rust (*Puccinia purpurea*), *bajra* rust (*P. Penniseti*), linseed rust (*Melampsora Lini*), rusts on indigo, lentil, lucerne, etc. (species of *Uromyces*), several members of the genus *Peridermium* on conifers, teak rust (*Uredo Tectonæ*), castor oil rust (*Melampsorella Ricini*), etc. The *juar* and *bajra* rusts were considered identical by Barclay and described as *Puccinia Penniseti*. They differ however in several important particulars and must be considered two distinct species. Information is

required regarding their life-histories and the extent of the damage caused by them. The linseed rust is very destructive. At Pusa this year it was confined to indigenous varieties and imported flaxes were entirely free. As botanically both plants belong to the same species this affords an indication that the breeding of a rust-resistant linseed is possible.

16. **Sugarcane diseases.**—The most important is red-rot, the disease induced by *Colletotrichum falcatum* which has been so destructive on the East Coast and in Bengal, and which is common elsewhere. Inoculation and field observations both point to the probability of the disease being conveyed chiefly in the canes used for planting and not primarily by spores. The field observations were carried out mainly in Behar where the recent development of sugar manufacture and planting in European hands has directed particular attention to it. In the localities where it was chiefly observed the disease was confined to one variety of cane. The fungus was found in the young plants of this variety and numerous cultures obtained from sets prepared for planting. Spore production was scanty in the fields, and it was found that other varieties could be planted in the diseased land provided that they came from healthy stock. This year inoculations from cultures grown on raw cane, and therefore not likely to have lost their virulence as a result of artificial culture, were tried both on sets at planting and on growing canes. No disease resulted though the canes were grown in boxes to maturity and the fungus preserved its vitality in the short length of cane tissue which it had been able to infect. Further experiments will be required to establish that the disease is seed-borne, and the work is being continued. The outlook is hopeful, for should this view be confirmed, treatment will resolve itself into the selection of unreddened sets for planting, a simple matter. The effects of a rigorous selection of healthy sets for planting on the resulting crop was apparent at Pusa, where 23 varieties from different parts of the country were grown in 1903-04 under somewhat unfavourable conditions. They gave on the whole excellent results, in spite of having had in several cases to undergo a long railway journey. The analyses, which were conducted by an assistant from the Agricultural Chemist's office kindly lent for the purpose, gave as an average of the 23 varieties 18·13 cane sugar and ·498 glucose, while excluding six varieties grown under the shade of trees in unsuitable soil, the remaining varieties gave an average of 19·11 cane sugar and ·380 glucose. As the object in view is to

establish a stand of healthy cane for future experiments at Pusa, an area of over 5 acres has been planted this year with these varieties submitted a second time to careful selection under my supervision.

17. A set-rotting fungus, *Sphæronæma adiposum*, was found in Behar and Dehra Dun in 1903-04. Its life-history, which possesses several points of interest, was followed and the relations of its different spore forms determined. Experiments to test the infection of sets in the field failed through an attack of white ants, but the fungus was found capable of rapidly rotting cut canes in the laboratory. An examination of failed sets obtained in the vicinity of Dehra Dun in 1904, gave this fungus as the apparent cause of the rotting in 61 cases, *Diplodia cacaoicola* in 6, *Schizophyllum commune* (a doubtful parasite) in 5 and white ants or rot from undetermined causes in 89 sets. Inoculations made in 1904 showed that this fungus does not readily attack growing canes.

18. The "pine-apple-disease" producing fungus *Thielaviopsis ethaceticus*, which is very destructive to cut sets in other countries, has not been found indigenous in India, but two occasions have come to my notice of its introduction from Java and Mauritius in both of which I was able to obtain the destruction of the consignment. As the monetary loss in one of these cases was considerable, and as the danger of introducing into India cane diseases from other countries is a very real one, I made the following suggestions for Government action in 1903:—(1) that cane imports for the purposes of field cultivation should be prohibited; (2) that importation for experimental cultivation should be permitted subject to the proviso that full information should be supplied to the department of agriculture and the cane be liable to inspection and to compulsory destruction should it be found diseased; and (3) that the departments of agriculture should be exempted from the action of these checks. Under case (2) the question of the advisability of providing compensation was raised. Government did not however consider that the time had come for such action, and it was decided only to issue through the press a warning against the introduction of diseased canes from Java and Mauritius.

19. Various other diseases of the leaf and stem of sugarcane were investigated in Bengal in 1902 and 1903, and a full illustrated account has been completed since May 1904, but the printing of the plates has delayed its publication.

20. **Fermentation of cane sugar by fungi.**—In June and July 1904, the effect produced by the two fungi *Colletotrichum falcatum* and

Sphæronæma adiposum on solutions of cane sugar was investigated in conjunction with the Agricultural Chemist. The loss of crystallisable sugar caused by the red-rot disease, due to the first of these, is altogether out of proportion to the area of cane infected which is often only one or a few internodes. Proof was obtained that this results from the action of sugar-inverting ferments produced by the fungi, that of *Sphæronæma* being considerably the more active. It appeared probable from the experiments that the ferment is not diffusible but is formed and remains within the cells of the fungi.

21. **Spike disease of sandal.**—The sandal-growing areas in Mysore and Coorg infected with this disease were visited in 1902, 1903 and 1904. No parasitic cause was discovered. The other causes assigned, such as fire, poor soil, want of shade, the presence of the Lantana shrub, which has invaded a considerable portion of the infected area, etc., were found to be insufficient to account for the facts. Observations regarding the infective nature of the disease were made and its extension watched. A large number of inoculations with different parts of the diseased tissues were tried but all have failed to take. As the prosecution of the enquiry would entail prolonged investigation carried out on the spot, the disease being most obscure, and as my time is fully occupied elsewhere, I was obliged to abandon the work until a more favourable opportunity arises. A note was published in the *Indian Forester* in 1903 and a critical examination of the views expressed on the disease by the Conservator of Forests, Mysore State, in the same in 1904.

22. **Tea and coffee diseases.**—A number of these have been seen in Assam, Dehra Dun and South India. Red rust caused by the *Alga, Cephaleuros virescens*, is probably the most serious tea blight. It was found widely distributed on jungle trees and shrubs and can doubtless pass to tea from these. From its absorbent character it was considered probable that spraying with Bordeaux mixture would prove advantageous, and this practice has been recommended by the scientific officer of the Indian Tea Association as a result of his experiments with it on tea estates. Thread-blight which is prevalent on tea in some districts appears to spread mainly by the blowing about of attacked leaves, some experiments in 1902 indicating that it cannot attack the bushes from below as was suggested by the Kew authorities at one time. Stump-rot or root-rot caused by various members of the genus *Resellinia* is common on both tea and coffee estates. These diseases

ordinarily originate in old rotting jungle or shade tree stumps. Hence on cleared jungle land they may become alarmingly frequent. Where, however, the nature of the disease is understood and prompt measures are taken, the damage can often be checked. Certain trees only seem capable of starting the disease as they rot, and the destruction of the roots of these by uprooting or burning out, has in some places been found practicable. As the number of foci of disease is often small and as propagation normally occurs through the upper layers of the soil, surrounding diseased areas by a trench is almost always successful in preventing its extension. Spore-production is not common and probably plays no considerable part in the history of the disease. A short note on stump-rot in tea and coffee was prepared for the South Mysore Planters' Association and printed in their Proceedings in 1903. Another root disease of tea which has appeared in a few localities was investigated in 1902. It was found due to an undescribed fungus of the genus *Diplodia*. Recently a serious coffee disease has appeared in the Nilgiris and Neliampatties. It is characterised by the dying back of the twigs, loss of leaves and rotting of the berries. It is constantly associated in the cases seen with a fungus (*Glœosporium*) to which the cause is assigned. Similar diseases are known to be produced by fungi of this genus and of the allied one *Colletotrichum* on orange and other trees. Experiments on spraying with Bordeaux mixture, the effect of wind belts, etc., are being carried out on an estate in the Nilgiris, but their result has not yet been reported. A number of other diseases was collected and an account of them will be published at a later date.

23. **Tur wilt.**—*Cajanus indicus* (*tur* or *arhar*) suffers commonly from a disease marked by the complete or partial drying up of the plant. It has been found over a large part of Northern India. The cause of the disease, which was first investigated in 1902, is a *Nectria* fungus which laboratory study has shown possesses four distinct spore-forms. Numerous experiments have been made in order to trace its mode of action. It is principally soil borne but also carried by the wind and possibly on the seed. Inoculations, chiefly made in 1904-05, have given very irregular results, the best being 20 per cent. of successes, while several series altogether failed. No explanation is available of this behaviour.

24. **Pepper diseases.**—The pepper vine disease in Malabar which has caused very great losses in the Wynaad and appears to be endemic on the Malabar coast was found constantly associated with a *Nectria*

which on cultivation in the laboratory proved to be indistinguishable from that of the *tur* wilt above-mentioned. As the causal connection has been proved by inoculation in the latter case, and as the two diseases are entirely similar in their pathological aspects, little doubt remains that they are identical. Arrangements were made for inoculation on pepper vines grown for the purpose by the Government Botanist, Madras, but the illness of Mr. Basu, who was deputed to carry them out, obliged their abandonment while still unfinished. Delays and difficulties of this character are inseparable from work attempted at a distance from head-quarters. The treatment of these wilt diseases resolves itself into the attempt to obtain resistant varieties, for they are not amenable to direct treatment. In the case of an annual like *tur* this should not be too difficult and varieties have been got together for the purpose at Kirkee and other farms. In a slow growing plant like pepper it becomes a formidable problem. The newly established pepper station in Malabar will no doubt be able to devote attention to this subject.

25. A second pepper vine disease has been known for a number of years in the Mysore ghat tracts. Instead of mere drying up of the vine without injury to the standard or living tree on which it grows, as in the case of the Wynaad disease, vines and standards are killed out in patches in this other form. The examination of a large number of specimens sent to Dehra showed the disease to be caused by one of the root rotting parasites of the genus *Rosellinia*. The particular species proved to be *R. bunodes* which has not previously been noted as a parasite. Treatment is hopeful in this case as the number of foci of disease is usually small and propagation can probably be checked by trenching as in the case of the similar diseases of tea and coffee.

26. **Other wilt diseases.**—Similar diseases to the pepper and *tur* wilts have been observed in Deccan hemp, soy bean and fennel, but the *Nectria* stage was not found. A gram wilt is also prevalent at Poona but the fungus concerned has not been isolated.

27. **Ground-nut leaf disease.**—A disease known in Bombay as *tikka* disease is a cause of much damage to the ground-nut crop in Bombay and Madras. It is caused by the fungus *Septoglœum Arachidis* first described from Java in 1898, and found also in German East Africa. The leaves are attacked and become covered with dark spots surrounded by a yellow areola, later on falling off. Nuts produced on badly attacked plants are shrivelled and worthless. Spraying with Bordeaux Mixture was tried at the Kirkee farm in 1903, but the results

were not conclusive. An experiment was made in 1904 to test the conveyance of the disease in the seed or in soil. Seed from Poona where the disease is common was sown in Dehra Dun where the crop is unknown and where the danger of air-borne infection might be neglected. Some plots were sown without further treatment while to others was added soil from a field at the Kirkee farm which had borne a diseased crop the previous year. All the plots took the disease indicating a probability that infection can be transmitted by the seed. Seed treatment is being tried this year at Pusa on the seed obtained from this diseased crop. As the amount of damage caused varies with the degree to which the nuts have formed before the attack begins, an attempt has been made this year by sowing a couple of months before the rains to produce an early crop.

28. **Oat smut.**—Treatment of oat seed with formaline and copper sulphate against smut was tested in 1904-05 at Dehra Dun. The plots were about ½ bigha in size. On the untreated plot 172,495 smutted ears to the acre were found. On the formaline plot, treated by soaking the seed for 4 hours in ·1 per cent. formaldehyde, 1,092 smutted ears only appeared, while the two copper sulphate plots, treated respectively with ⅓ per cent. and 1 per cent. by soaking for 24 hours, gave 2,115 and 1,069 smutted ears. The prolonged treatment with copper sulphate injured germination considerably especially with the 1 per cent. solution, while giving no better results than the formaline which was not injurious. The latter is, therefore, considered the more satisfactory. As smut is very bad in Dehra Dun, affecting about 10 per cent. of the ears, an attempt will be made this season to introduce the treatment into practice. It is extremely simple in application.

29. **Other smuts.**—Smuts of wheat (*Ustilago Tritici*), barley (*U. Hordei*), rice (*U. virens*), sawan millet (*U. Panici-frumentacei*), etc., have been frequently obtained and indications for treatment given.

30. **Sorghum diseases.**—*Juar* suffers from a number of fungus diseases. Besides rust, already mentioned, the following have been investigated:—Smut: two varieties are common, caused by different fungi, *Ustilago Sorghi* and *U. Reiliana*. The former can be successfully treated with copper sulphate and experiments are in progress to determine at what stage infection occurs and to compare formaline and copper sulphate treatments. The germination of the spores has also been followed as a preliminary to tracing the complete life history. *Colletotrichum Lineola* is a common cause of a leaf-disease and *Phyllosticta sorghina* has been found causing a somewhat similar

affection. A curious leaf shredding disease has also been observed but the fungus associated with it has not yet been determined.

31. **Green ear disease of the bulrush millet.**—A common condition of the *bajra* millet, in which the whole ear becomes converted into a brush-like head with transformation of the floral leaflets into small distorted foliage leaves and no formation of grain, has been noticed in Bombay, the Punjab and Madras. The cause was determined last year to be an undescribed fungus of the genus *Sclerospora*, other members of which similarly affect various cereals. The life-history of this fungus remains to be worked out, and treatment cannot be suggested until it is known how it originally attacks the plant.

32. **Diseases of trees.**—A large number of diseases of fruit and forest trees have been investigated in the past three years. The deodar forests in Jaunsar are much damaged by the root fungus *Fomes annosus*. Its mode of action was studied and extension found to depend largely on the production of rhizomorphs or organised strands of fungal tissue. Their occurrence in this species was not previously known and influences considerations regarding treatment. The effect of the fungus on deodar wood was also examined. An account was published in the *Indian Forester* in 1903. A second disease caused by the rust *Peridermium Cedri* has recently been obtained on the same tree, and is said to cause much damage to young plants. *Pinus excelsa* is attacked by *Trametes Pini* near Simla, specimens having been received in 1904. It was not previously known to exist in India though a serious pest in German forests. A babul disease has been reported to be destructive in the Berars. Its cause has been ascertained to be *Fomes Pappianus*, a fungus not previously reported as a cause of disease, but found in Abyssinia on acacias. The casuarina plantations on the East Coast are attacked by a disease in some places. The cause was found on examination at Chatrapur in 1904 to be an undescribed fungus of the genus *Trichosporium* which attacks the base of the tree. A description has been drawn up including some suggestions for treatment and communicated to the Madras Government and the Forest officers concerned. It has been incorporated in some notes on Indian forest fungi which have been sent for publication in the *Indian Forester* and will contain a description of a number of forest pests. Peach leaf-curl caused by *Exoascus deformans*, and leaf diseases of mango, loquat and other fruit trees have been obtained from various localities.

33. **Vine diseases.**—Powdery mildew caused by the vine *Oidium*

and *anthracnose* due to *Sphaceloma ampelinum* were seen at Poona, Shillong, and elsewhere and remedial measures carried out.

34. **Betel palm diseases.**—Two serious diseases of this valuable palm have been investigated. In Mysore a disease known as *Koleroga* was seen in 1903, and its probable cause ascertained to be a *Phythophthora*. Further enquiry has not been possible. In Sylhet the disease known as plague is causing great ravages, and was studied locally in May, 1905. It is of recent origin and due to a fungus which attacks the base of the tree. Its treatment is likely to be extremely difficult and a total loss of many of the gardens is to be feared. The nature of the fungus has not yet been ascertained with certainty.

35. In addition to the above a large number of other diseases of cultivated crops has been received for examination or seen on my various tours. Wherever possible recommendations for treatment have been given.

IV. OTHER INVESTIGATIONS.

36. **Kodra poisoning.**—The poisonous properties often possessed by the grain of kodra (*Paspalum scrobiculatum*), a cereal much grown by the poorer classes in various parts of India, have been more than once referred to some abnormal condition produced by a disease of the plant. Several specimens were obtained from Bombay and the presence of a fungus detected in the seed coats and less frequently in the endosperm. A sample of grain which had actually produced poisoning was obtained in Behar in 1903. Grown in Dehra Dun in 1904 the resulting grain was found to produce the peculiar symptoms of vertigo, etc., in man when eaten. Thirty-seven per cent. of the seeds were found to contain the fungus. Experiments were made with rabbits and rats but neither appeared to suffer from eating the poisonous grain. They are being continued, but until a suitable animal is found for experiment the influence of the fungus cannot be determined. An analogous case, that of *Lolium temulentum* which appears to owe its poisonous properties to a fungus inhabiting the seed coats, and which is at present the subject of investigation from this point of view in Europe, gives an indication that we are on the right track.

37. **Mycorhiza.**—It has long been known that a number of plants live in combination with a fungus which inhabits their roots. To the combination the name mycorhiza has been given. In many cases the fungus occupies the interior of the root and a large number of such "endotrophic" mycorhizas has been examined in the past three years.

The case of the nodule bacilli of the *Leguminosæ* and the evident fact that the plant does not suffer from the association suggests that such mycorhizas play a part in plant nutrition. Experiments to investigate this have been in progress for some time. The fungus has been found in all the cases examined (over 50) to be identical. It refuses to grow satisfactorily in artificial cultures and has never been observed to produce spores. Its handling is, therefore, a matter of much difficulty, and the experiments in progress have not yielded results of much value. It has not been possible to attack the problem seriously owing to constant touring, and the work so far has been mostly preliminary.

38. **Nodule bacilli of Leguminosæ.**—Experiments were started in April, 1905, at the instance of the Inspector General of Agriculture, to determine the effect of inoculation of leguminous crops with bacilli in the manner recently recommended by the United States' Department of Agriculture. The principal departure in this method from those already adopted with varying success in other countries consists in growing the bacilli on non-nitrogenous culture media. In a preliminary test three lots of 30 seedlings each of *tur* (*Cajanus indicus*) were grown in sterilised soil. One lot was inoculated with bacilli prepared according to the method advocated by the United States Department, a second with bacilli grown on media containing nitrogen and the third left uninoculated. Examined after five weeks 404 nodules were found on the first lot, 32 on the second and one on the third. No conclusions can be drawn from a single experiment of this nature. Field tests are being carried out both at Dehra Dun and Pusa, and their results should be of considerable interest. In the case of a widely grown crop like *tur* no great advantage can be expected to result from the practice since the bacilli are doubtless present in the soil in which it is habitually grown, unless it should prove to be the case that bacilli starved of nitrogen are more virulent than those normally present in the soil. The further enquiry is in the hands of the Agricultural Bacteriologist.

39. **Miscellaneous.**—A commencement has been made this year in the collection of the edible fungi of India, which are very little known. A collection of mildews, caused by lower forms of the *Eryiphaceæ* whose identification is very difficult, has been recently sent to Mr. E. S. Salmon at Kew who is monographing the group. Several collections of members of the interesting family of the *Gasteromycetes* have been sent for identification to Professor Lloyd of Cincinnati, who proposes to issue a monograph of the Indian forms. Some fungi

probably concerned in the retting of jute were received from the Special Jute Expert to the Bengal Government in 1905 and their identity determined.

40. A list of publications will be found at the end of this report.

E. J. BUTLER, M.B., F.L.S.,
Cryptogamic Botanist to the Government of India.

Dated the 13th July, 1905.

RYAN, G. M. . . Water-yielding plants found in the Thana forests. *Journ. Bombay Nat. Hist. Soc.*, xvi, No. 1, p. 65.

SPIRE, C. . . . Contribution à l'étude des Apocynees indo-chinoises. *Trav. Labor. Mat. Med. Paris*, 1904. Tom. 2, Part 4.

STAPF, O. . . . On the fruit of Melocanna bambusoides. *Trans. Linn. Soc.*, 2nd Series, vi, Part 9.

STAPF, O. . . . Arundinaria Falconeri. *Bot. Mag.* 3rd Series, lx, t. 7947.

AGRICULTURAL BOTANY.

BY

E. J. BUTLER, M.B., F.L.S.

Cryptogamic Botanist to the Government of India.

Cereals and food stuffs.—The office of the Reporter on Economic Products has carried nearly to completion the botanical study of the varieties of *juar* (Andropogon Sorghum) grown in India, and the report will soon be ready for the Press. The extent of this inquiry may be grasped from the fact that in Madras alone the Government Botanist has accumulated 680 sheets of specimens, exclusive of sorghum diseases. The investigation of the plants yielding yams, carried on in the same office in collaboration with the Superintendent, Royal Botanic Garden, Calcutta, has also advanced. Similar inquiries on chillies, plantains and Burmese pulses are in progress in the Reporter's office, and the information obtained regarding the latter is almost ready for publication. The Government Botanist, Madras, is engaged on a detailed study of the different varieties of sugarcane at the Samalkota sugar station, which has been enlarged and made permanent during the year. This inquiry includes not only the botanical characters of the varieties but also their agricultural value as regards yield, purity of juice and resistance to red rot. Some Mauritius canes imported into Vizianagram a few years ago were tested both at Samalkota and Pusa, and gave excellent results. Some Barbados seedlings have also been

introduced at Samalkota and their acclimatisation is being attempted. It has been established by Mr. Barber that some of the canes which flowered at Samalkota produced fertile seeds; this opens a way to experiments in the production of seedling canes which have proved so successful in other countries. The Reporter on Economic Products has in hand investigations of the Indian varieties of caraway (Carum), pan (Piper Betel), barley, wheat, Goa bean, and the rice known as Oryza coarctata. Collections of edible mushrooms are being made at the Indian Museum and by the Cryptogamic Botanist working conjointly. A list of famine foods is under preparation in the office of the Reporter. The scientific study of groundnut and black pepper, both of which important crops in South India are falling in cultivation mainly owing to fungus disease, has been provided for by the founding of two experiment stations by the Madras Government. One of these at Palur, in South Arcot, is intended for groundnut and subsidiary crops, and the other at Taliperamba, in Malabar, for pepper. They have been placed under the general control of the Government Botanist, Madras. Professor Wyndham Dunstan, Director of the Imperial Institute, London, has issued a report on the poisonous properties of Lima bean (Phaseolus lunatus), which has been published in the Agricultural Ledger for 1905. His results go to show that while the semi-wild forms grown in Mauritius contain considerable quantities of a glucoside, yielding prussic acid on fermentation, cultivated forms from Burma possess a lesser but variable amount. He recommends the cultivation of the white variety of bean as being the least dangerous in this respect. Major Buchanan's report on the disease known as lathyrism in India, produced by eating Lathyrus sativus, has not yet been published.

Fibres.—The study of cotton, with a view to the extension and improvement of cotton cultivation in India, has attracted a great deal of attention during the year. A detailed account of the work in progress in the several Agricultural departments was published in the Proceedings of the Board of Agriculture in India, in January 1905. The present series of correlated experiments in nearly every Province of India may be considered to have originated in 1902, when the Inspector-General of Agriculture in India collected as complete a set as possible of the existing varieties, submitted them to a preliminary examination and

distributed them to the experiment stations of the principal cotton tracts as a basis for further study. The botanical investigation of Indian cottons was taken up by Professor Gammie; and his second paper, dealing with the species and varieties known in India, their respective areas of distribution, the important question of the degree to which hybridization naturally occurs, the quality of the lint and other similar matters, is now in the press. Mr. Burkill toured in Burma and the Nizam's Dominions for the purpose of studying the cottons of these tracts, and has submitted to Government two notes on the results obtained. In Burma he distinguishes six kinds, and possibly a seventh, two only being of importance, and furnishes notes on their distribution, cultivation, value and the disposal of the produce. The Inspector-General of Agriculture issued a report on the possibilities of extending cotton cultivation in Burma, in which the economic conditions governing the question are dealt with, and proposals are made for testing the behaviour of native and exotic varieties in the different soils of the dry zone, and for improving the local varieties by seed selection and otherwise. He points out, however, that no establishment exists in Burma for carrying on such work. Two notes have been issued on cotton cultivation in Behar by the Inspector-General of Agriculture and by the Entomologist to the Government of India. The former contains proposals for definite experimental work and a preliminary review of the results obtained in the first two years' trials with Indian and exotic varieties. In Mr. Lefroy's note the behaviour of these varieties during 1904-05 is reviewed and the extent to which they were affected by the climate. Acclimatised Americans gave some small promise of ultimate success. The insect pests of cotton in Behar are also briefly described in this note. Mr. Sly, Officiating Inspector-General of Agriculture, inspected the tree cotton experiments of the Indian Long Staple Cotton Growing Syndicate (agents, Messrs. Shaw, Wallace and Co.) and published a note describing them and suggesting improvements. Attention has recently been directed to this class of cottons—perennials—which are usually found in gardens and temple compounds and the lint of which, sometimes fine in quality, is almost exclusively used for weaving the sacred thread of the higher castes. A large number of varieties has been collected from all parts of India, and these are being tested on a considerable

scale by the Indian Long Staple Cotton Growing Syndicate and on a smaller scale elsewhere. Hybridization of cotton is still in progress at the Bombay Farms and elsewhere, and the results are sufficiently advanced in Bombay to hold out considerable hopes of valuable results. It is already fairly clear that no other line of cotton work equals this in its prospects of ultimate success. The trial of long-stapled Egyptian cottons in Sindh by Mr. Fletcher, Deputy Director of Agriculture, Bombay, has given some promising preliminary results. The continuation of these experiments will be watched with the keenest interest. Fifteen-hundred acres have been sown this year to provide a test on a fairly large scale. Extensive arrangements have been made for the selection of the best seed of local varieties in several cotton tracts, with a view to assisting cultivators to improve their crops. The co-operation of ginning factories has been enlisted in some places, as they can materially assist by separating good seed and issuing it, after ginning, to the cultivators. In other places field-to-field selection is being undertaken. This work is independent of the plant-to-plant selection, which is carried out chiefly on the experimental farms.

Jute investigations, taking their origin in complaints of deterioration in the produce made by the trade some years ago, have been continued during the year and the first stage completed by the issue of a report on "Deterioration of Jute in Bengal" by Sub-Committee B of this Board on September the 19th, 1904. As a result of their inquiries the Sub-Committee report that "there is not only no proof that any deterioration in either of the jute plants has occured, but there is a strong evidence that the plants are now precisely as they were a century and more ago. The best kinds, now as then, if cultivated liberally, yield excellent crops, and their fibre, if properly extracted, is also excellent. * * * There is no indication that any radical change has come over the system of steeping and retting, but there appears to be proof that at times fraudulent watering, which induces heating and discolouration, is resorted to with the object of fictitiously increasing the weight of the fibre offered for sale." They, however, express the opinion that "though this is no doubt the explanation of some of the deterioration observed and complained of, it does not explain it all; and in their belief the degeneration is largely due to the fact that whereas formerly only the

best jute, or at all events the jute most suitable for purposes of the Dundee and Calcutta spinner, alone found a sale among jute dealers, now these dealers require so much jute that to fulfil their obligations they must purchase practically whatever jute is offered to them, knowing as they do that what one dealer refuses to buy another will come forward and secure." Experiments are in progress at the Burdwan and Pusa farms, where the most suitable varieties are being tested and the problems connected with jute cultivation studied. Mr. Finlow, special jute expert with the Government of Pengal, has made a preliminary study of the fungus flora of the retting waters, assisted by the Cryptogamic Botanist, and has also commenced an investigation of the bacteria concerned in the process of retting.

Agave fibres still attract much attention. The Botanical inquiry into the identity and distribution of the various agaves and Furcrœas by Lt.-Col. Prain and Mr. Drummond was recently finished and is now in the Press. A valuable bulletin on Sisal Hemp Culture in the Indian tea districts by Dr. Mann and Mr. Hunter was issued by the Indian Tea Association. The Aramina fibre of Brazil, which has attracted some notice, has been grown in the Calcutta Botanic Gardens and identified as Triumfetta rhomboidea, a common tropical plant of no special value as a commercial fibre producer. At the same institution the inquiry into the sources of Indian or Sunn hemp, Crotalaria juncea, was continued, the fibre of plants grown from various parts of the country having been sent to England for valuation. The investigations of the fibres of Calotropis and plantain have been continued in the office of the Reporter on Economic Products.

Dyes and tans.—Three papers dealing with Indigo were published by Mr. Leake. He has investigated the localization of the indigo producing substance in the plant by improved methods, and finds that the results of earlier workers cannot be considered proved. The variations induced in Indigofera sumatrana by climatic conditions are considered in a second paper and elucidated by maps. Both the lines of equal rainfall and equal temperature enclose areas agreeing with the areas in which the various types are found. This throws some light on the question of the choice of the locality for seed areas. In a third paper the occurrence of hard seed in Indigofera arrecta, "Natal" Indigo, is

noted and suggestions for treating the seed-coat are made. This indigo, which is now so highly thought of in Behar, germinates with such difficulty that seed treatment is likely to become habitual. Some simple machines for the purpose have already been devised. The Government Botanist, Madras, has collected some South Indian varieties of Indigofera, particularly the rare I. longeracemosa and I. Anil, for trial at the Palur farm.

Mycology and plant Pathology.—A bulletin by Messrs. Mann and Hutchinson on "red rust" Cephaleuros virescens of tea was issued by the Indian Tea Association. It contains the results of careful observations and experiments carried on over several years. The life history of the parasite and relations between it and the host plant are described and recommendations for treatment given. The general conclusion of the authors is that it is a disease primarily induced by weakness of the tea bush due to unsuitable soil, want of drainage and bad cultivation. Vigorous, well cultivated gardens are rarely damaged. The same Alga was found by the Cryptogamic Botanist to produce a serious disease of mango trees at Malda, possibly the most important mango growing district of India. Grafts chiefly are affected, the parasite attacking the young twigs and producing their death eventually by destruction of the bark. The analogies with the attacks on tea were very evident. A second mango disease, due to Gloeosporium Mangiferæ, is destructive to the young flushes in Dehra Dun.

In the Cryptogamic Botanist's office the wilt disease of arhar, Cajanus indicus, has been further studied and the pepper disease of the Malabar district was found associated with the same fungus, a species of Nectria. A note on the latter was published in the Proceedings of the Wynaad Planters' Association in October 1904, and a detailed account of the two diseases has been recently submitted for publication. A second pepper disease occurs in Mysore, due to one of the root rotting fungi, Rosellinia bunodes, and instructions for its treatment have been issued to those concerned. Groundnut *tikka* disease (Septoglœum Arachidis) is still under study; a second disease of this crop, less destructive than the other, has been noted this year at Dehra Dun. Rice smut and *chhatra* disease of paddy are under study. The latter was found in some cases associated with the fungus Sphaerella Malinverniana

to which has been ascribed similar diseases in Italy and Japan, but it was not always discovered on diseased plants. Several new coffee diseases have been investigated, one of which, examined locally in the Nilgiris, appears to be very serious. It is apparently caused by a species of Glœosporium which attacks the twigs. Experiments in its treatment are in progress. In Sylhet several of the coffee diseases prevalent in South India were found established in an estate visited. The Areca palm plague in the same district was investigated and determined to be due to a fungus attacking the base of the palm, the exact nature of which is not yet known. A report was submitted to the Assam Department of Agriculture from which a vernacular leaflet, giving some suggestions for dealing with it, is in preparation. A serious outbreak of disease in Palmyra, cocoa and areca palms in the Godávari Delta was also investigated, the cause here being a species of Pythium which attacks the leaf stalks and terminal bud, thus killing the tree. The inquiry is still proceeding. The disease of sisal hemp due to Colletotrichum Agaves has been reported from several districts and was studied in Sylhet. Suggestions for treatment have been given. Two rubber diseases have been examined, the canker of Hevea from Burma and a Botryodiplodia disease of Castilloa elastica from the Anamalis, and treatment recommended. The rust of *juar* (Andropogon Sorghum) and *bajra* (Pennisetum typhoideum) have been identified and have proved to be distinct species, contrary to the opinion of the late Dr. Barclay. "Green ear" disease of the latter cereal was found to be induced by the attacks of a new species of Sclerospora on the leaves. It is still under study. Amongst the most serious diseases reported during the year is the cotton wilt of the Punjab, which appears to be the same as that which has been one of the worst enemies of the cotton cultivation in the United States. The area affected is probably small and efforts will be made to stamp it out, but it must remain for some time a cause of much anxiety. A somewhat similar disease has been found on jute. The mildews which affect a number of Indian crops are being studied by Mr. E. Salmon at Kew, to whom collections have been sent. Tobacco, mulberry, orange, several pulses, castor oil, wheat, coriander and Trigonella are amongst the plants attacked.

The poisonous properties of the cereal *kodra* (Paspalum scrobicu-

latum) are under study in the Cryptogamic Botanist's office, as there is some reason to believe that they result from a fungus often found in the grain.

The work on wheat rusts carried out in conjunction by the Cryptogamic Botanist and the Deputy Director of Agriculture, United Provinces, was continued. A paper was completed by them in 1904 but has been delayed in publication. This gives details of the chief rusts, considers their mode of transmission from year to year, their specialisation on different host plants and the influence of meteorological conditions on the disease. Mr. Moreland has contributed a note on the latter point based on observations in selected districts of the United Provinces during a number of years. A short note by the Cryptogamic Botanist on the degree to which the liability of wheat to rust depends on secondary infection by Uredospores rather than on the severity of the first outbreak of the disease is in the Press.

The paper on sugarcane diseases in Bengal submitted by the Cryptogamic Botanist in the first half of 1904 has not yet appeared owing to delay in publication. The Government Botanist, Madras, is endeavouring to raise canes resistant to red rot at the Samalkota farm and is continuing his study of the behaviour of different varieties of cane to it.

Mr. A. Nechitsch, of Geneva, has investigated the fungi producing the fermentation of alcoholic beverages prepared from rice in Sikkim and the Khasia hills. The chief fungi concerned are named Mucor Prainii and Dematium Chodati. Their fermentative activity under different conditions is described.

The preparation of a text book on plant diseases in India has been commenced by the Cryptogamic Botanist.

Miscellaneous.—A large number of references to the economic and agricultural uses of certain plants in Burma and Bengal occur in Vol. 3 No. 1, No. 2 of the records of Botanical Survey of India by Captain Gage and Lt.-Col Prain, respectively.

The use of copper sulphate in purifying tank and well waters by killing algæ and bacteria without injuring the higher forms of life, as described by Dr. Moore of the United States Department of Agriculture, has been extensively tested in India during the year. Dr. Cook, Health Officer, Calcutta, Dr. Turner, Health Officer, Bombay,

Lt. Christophers, Superintendent, King Institute, Madras, and others have issued reports on the results of their trials. Dr. Cook states that he is reluctantly forced to the conclusion that copper sulphate in the quantities prescribed by Drs. Moore and Kellarman is of little practical use for the purification of the filthy tanks that abound in Calcutta. The other workers generally arrive at the same conclusion. Interesting notes are supplied in Dr. Cook's report on the algal vegetation of Calcutta tanks.

The following papers dealing with Agricultural and Economic botany appeared during the year.

1. Proceedings of the Board of Agriculture in India, 1905.

2. Agricultural Ledger No. 2 of 1905, Phaseolus lunatus (Lima or Duffin Bean).

3. Note on Cotton Experiments in Behar by J. Mollison.

4. Notes on Cotton in Behar by H. Maxwell-Lefroy.

5. Report on Cotton in Burma by I. H. Burkill.

6. Notes on Cotton made at Bhainsi, Nizam's Dominions, by I. H. Burkill.

7. The cotton experiments of Messrs. Shaw, Wallace & Co. by F. G. Sly.

8. Selected papers on inquiry into deterioration of jute, Government of Bengal.

9. The localization of the Indigo-producing substance in Indigo-yielding plants, by H. M. Leake: Annals of Botany, XIX.

10. The occurrence of "hard seed" in Indigofera arrecta *Hochst*, by H. M. Leake: Journal, Royal Horticultural Society, Vol. XXIX, pts. 1 & 2.

11. Variation in Indigofera Sumatrana Gaertn. as induced by climatic conditions, by H. M. Leake: Journal Royal Horticultural Society, Vol. XXIX, pts. 1 & 2.

12. Sisal hemp culture in the Indian Tea Districts, by H. H. Mann and James Hunter. Indian Tea Association, No. 3 of 1904.

13. Progress report on the work of the Samalkota Experimental Sugar Farm during 1903-04, by C. A. Barber.

14. Red Rust: a serious blight of the Tea plant, by H. H. Mann and C. Hutchinson, Indian Tea Association No. 4 of 1904.

15. Sur les ferments de deux levains de l'Inde, le Mucor Praini et le Dematium Chodati, by A. Nechitsch, Institut de Botanique, Université de Genève, 6e. ser., Ve. Fasc. 1904.

16. Pilzkrankheiten in Indien im Jahre 1903, by E. J. Butler, Zeitschrift fur Pflanzenkrankheiten, Bd. XV, Heft 1.

17. Pepper vine disease, by E. J. Butler, Proceedings Wynaad Planters' Association, October 1904.

18. The uses of Copper as an Algicide and Germicide by Dr. J. Nield Cook, Calcutta, July 1905.

FOREST BOTANY.

BY

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The subject matter of this part of the report has been roughly divided into two sections according as the work recorded has been carried out by members (active or retired) of the Forest Department, or by investigators outside the department. This division cannot be absolute, as much work in Forest Botany is done conjointly.

Section I. By far the most important work under preparation during the year has been that by Sir D. Brandis entitled "Indian Trees," of which Part I has already been some time in print and the greater part of Part II is now in the Press. A considerable number of specimens have again been forwarded to Sir D. Brandis from various officers during the year, many of which however have arrived too late to be made use of.

Of new species actually published there have been but few. Lindera aromatica *Brandis* appeared in Hooker's Icones [1] and Mr. Bourdillon has published in the Indian Forester [2] plates as well as descriptions of the following trees:—Dialium travancoricum *Bourd.* a magnificent evergreen tree from South Travancore. This tree was provisionally referred to D. coromandelianum *Houtt.* in Gamble's Manual. Eugenia Rama-Varma *Bourd.* from the evergreen forests of Travancore and Tinnevelly, and E. occidentalis *Bourd.* a small tree from the same parts.

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[1] Hook Icones Plant T. 2784. [2] Indian Forester, Vol. xxx. Nos. 4, 5, 6, 8.

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TROTTER, A. . . . Ulteriori osservazioni i tubercoli radicali de Datisca cannabina. *L. Bull. Della Soc. Bot. Ital.*, Nos. 3—4, 1906.

WILLIAMS, F. N. . . Liste des plantes connues du Siam. *Bull. l'Herb. Boissier*, 2nd Ser., 1902, pp. 428, 949.

AGRICULTURAL BOTANY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Cereals and Food Stuffs.—The difficult botanical investigation of the cultivated races of Juar (*Andropogon Sorghum*), grown in India, has been continued. A general botanical study of these is in progress in the office of the Reporter on Economic Products, and a first paper has been published as an Agricultural Ledger (No. 6 of 1905) on *Sorghum vulgare*—the Great Millet in India—by Sir George Watt. This will soon be followed by a fuller account of the races of Juar. In Madras a bulletin has been published on the same subject by Mr. C. Benson, Deputy Director of Agriculture, in which an account of the Madras varieties is given on the basis of a provisional classification by Mr. I. H. Burkill. Mr. Gammie, Economic Botanist, Bombay, has in hand a similar study of the Bombay races.

A considerable amount of information on the subject of wheat cultivation was collected for the second annual meeting of the Board of Agriculture, held in January 1906, and has been published as an appendix to the Proceedings of the Board. A further investigation has been taken up by Mr. A. Howard, Imperial Economic Botanist, who is compiling an account of the work done up to date, to be followed by a further botanical study. As a basis for accurate classification, Mr. Howard has accumulated most of the known Indian varieties at Pusa, where they have been grown during the past season and botanically examined. As was anticipated, most of the races were found mixed, and the separation of the types has proved a laborious matter. In addition to observing the varieties as grown at Pusa, Mr. Howard visited the Central Provinces and Punjab to study many of the chief kinds in their native homes. This inquiry should throw

some light on the correctness or otherwise of the statement often made that many of the races are liable to change their characters when introduced into other climatic areas. It is obvious that no accurate information on this point can be gained by working with mixed strains, as most of the so-called races have proved to be, and the first essential is therefore to obtain pure types for further investigation. These types have also provided material for hybridization work, and numerous successful crosses have been obtained. A scheme for future work on the improvement of Indian wheat was settled by the Board of Agriculture. Mr. Gammie has continued his botanical study of the varieties of wheat grown on the Poona Government Farms, and has also in hand a similar study of rices grown at Poona and Lonaola. An Agricultural Ledger on the rice known as *Oryza coarctata* is in preparation by the Reporter on Economic Products.

Mr. Burkill and Lieutenant-Colonel Prain are collaborating in a large review of the yams of India which is not yet completed.

Mr. Barber, Government Botanist, Madras, has continued his work on the varieties of sugarcane in parts of the Madras Presidency, and on those which have been introduced on the experimental sugarcane station at Samalkota. The imported Mauritius canes have been botanically examined in the field, and arrangements made with the Director of Forestry in Mauritius for their determination. This is intended to clear up the serious confusion which now exists as to the identity of these canes. Mr. Barber has also drawn up, for the Inspector-General of Agriculture, a scheme for inquiry into the sugarcane industry in India, to be conducted by the various provinces in preparation for the next annual meeting of the Board of Agriculture, where the subject will be fully discussed.

Mr. Burkill is engaged on a study of the races of *Lathyrus sativus* in India, and an account of the disease known as lathyrism, induced by the consumption of poisonous forms of this pulse, has been published by Major Buchanan.

Mr. Barber has prepared an illustrated account of the varieties of pepper growing in the Wynaad plantations which is published as a Bulletin of the Madras Department of Agriculture. Arrangements have been made at the special pepper farm at Taliparamba in Malabar, founded last year, for a full botanical and agricultural investigation of this important product.

The inquiries into Indian caraways, pan, barley, Goa bean, Burmese pulses, plantains, and chillies are still in progress in the office of the Reporter on Economic Products.

Experiments in the cultivation of dates (*Phœnix dactylifera*) have been started in the arid tract of Sindh, where the climatic conditions appear to be suitable. The best varieties have been obtained from many countries, and are now being tested. An account of the cultivation of date-palm has been published by Mr. Fletcher, Deputy Director of Agriculture, Bombay, as an Agricultural Ledger.

Fibres.—The work on the improvement of Indian cotton, alluded to in last year's report, has continued. The most important feature of the year has been the success in its preliminary stages of the attempt to introduce Egyptian cotton in Sindh, carried out by Mr. Fletcher, Deputy Director of Agriculture, Bombay. The cotton was under irrigation and after Egyptian methods, and some of the produce realised as high a price as 10*d*. per lb. in Liverpool. A considerable area (about 6,000 acres) has been sown this year, and the results should provide a reliable indication of the ultimate value of the experiment.

Mr. Gammie has published a paper dealing with the species and varieties of Indian cottons, their respective distribution, the quality of their lint and similar matters, and a revised account, with coloured illustrations of the chief types, is under preparation. A description of some Indian cottons which have not yet been studied in cultivation at the Government Farms is being prepared for publication by Mr. Burkill. The other lines of work on the improvement of Indian cottons, such as hybridization, the cultivation of tree cottons, and so on, mentioned in last year's report, are still in progress on various Government Farms and elsewhere, but no results calling for mention have as yet been published.

Mr. Burkill is collecting information regarding the varieties of jute in cultivation, in conjunction with the Department of Agriculture. Further experience has only confirmed the conclusions arrived at by the Sub-Committee of this Board, reported in 1904, that the alleged deterioration of jute fibre reaching the market is due, not to any deterioration of the plant itself, but to fraudulent watering and the shortage of supply which forces buyers to purchase even the most inferior qualities. The obvious remedy for this is the extension of the area under jute cultivation in India.

The inquiry into the source of "sunn" hemp was continued at the Royal Botanic Gardens, Calcutta. A paper on the botanical classification of Indian grown agaves, by Lieutenant-Colonel Prain and Mr. J. R. Drummond, is in the Press.

Oils, Dyes, Drugs, etc.—The botanical investigation of the lemon grasses (yielding citronella oil) has received special attention from Mr. Barber during the year. It has been made abundantly clear that the subject is involved in confusion and that detailed inquiry is necessary to obtain authoritative information regarding the value of the varieties yielding this important product. A method for treating the seed of the newly introduced Natal indigo to promote germination was suggested by the writer and has been elaborated by Mr. C. Bergthell, Imperial Bacteriologist, who is in charge of the indigo research station at Sirsah. It consists in immersing the seed in strong sulphuric acid for a definite period. The application is more simple than, and at least equally effective as, the cumbrous treatment by machinery previously used. A paper, giving the results of his investigation into the nature of the hard seed coat, has been prepared for publication by Mr. Bergtheil.

Several botanical specimens of trees allied to the camphor tree have been received from Burma by the Reporter on Economic Products, and these will form the subject of investigation with regard to their possible value as camphor yielders.

Tobacco improvement was the subject of a discussion at the last annual meeting of the Board of Agriculture, and a scheme for future investigation was drawn up. This will entail a certain amount of botanical work, but the botanical side of the enquiry has not yet been commenced.

Mycology and Plant Pathology.—Mr. Barber has contributed a note on the occurrence of the root parasitic weed *Striga*, on paddy, to the Agricultural Journal of India. This is but a part of a large investigation which the Madras Government Botanist has undertaken into the root parasites of Southern India. As, however, the majority of these are not agriculturally important, further mention is not required here. The addition of an assistant for mycology to Mr. Barber's staff has enabled him to carry out preliminary investigations of a number of plant diseases. The work of the special sugarcane, ground-nut, and pepper farms under Mr. Barber's supervision has been in part concerned with the diseases of these crops.

Dr. H. Mann, Scientific Officer of the Indian Tea Association, has issued a bulletin on the fungus disease known as "blister blight" of tea which is caused by *Exobasidium vexans*; the life-history of this destructive blight is given, out-breaks are shown to be the result of well-defined causes, and preventive measures are described. Mr. Hutchinson, of the same Association, has in preparation a technical account of the "red rust" of tea, caused by the alga (*Cephaleuros virescens*).

A considerable amount of systematic work has been done by the Imperial Mycologist, with assistance from outside India. Arrangements have been made for the publication of the Indian species of rusts and smuts in the Herbarium at Pusa, in conjunction with Herr H. Sydow of Berlin. About two hundred and fifty species have been collected, being nearly double the number of Indian species previously known, and these have been despatched to Berlin after the greater part had been named. The new species contain several forms of great interest. Collections of higher fungi have been sent to Mr. G. Massee, of Kew, who has published several new species in the Kew Bulletin. The collection of wilt disease producing fungi has been sent to Dr. W. Busse, of Berlin, for critical examination. Mr. E. Salmon, of Wye, has continued his interest in Indian mildews (*Erysiphaceæ*), and further collections have been sent to him. A monograph of *Pythiaceæ*, a group of lower fungi, has been written by the Imperial Mycologist and is now in the Press. Several minor collections of *Gasteromycetes* have been sent to Professor Lloyd, of Cincinnati.

The main work of the Imperial Mycologist has been, as usual, the study of plant diseases, of which the following are the chief. An account of the wilt disease of pigeon-pea and pepper was published in the Agricultural Journal of India, and further work with this disease is in progress. Sugarcane diseases are still under study, and a revised memoir on those prevalent in Bengal is published in the Memoirs of the Department of Agriculture in India. The checking of "red rot" (*Colletotrictum falcatum*), by far the most serious cane disease, has been found entirely practicable in Behar, and knowledge of the mode of spread of the disease has been obtained, which should be of much value. Work on cereal rusts has been continued, and an account of the observations made up to date, in conjunction with Mr. J. M. Hayman, Deputy Director of Agriculture, United Provinces, is also

published in the Memoirs of the Department of Agriculture in India. A brief note on the bearing of Mendel's laws of heredity on the susceptibility of wheat to rust was published in the Journal of Agricultural Science. Considerable alarm has been caused in the Godavari Delta by the outbreak of an epidemic disease of palmyra and cocoanut palms. The cause of the disease was determined, after a local investigation, the affected area mapped, and proposals made for an organized attempt to stamp it out before it extends further. All the indications point to the probability that it can be stopped by prompt measures, and the suggestions made for treatment are under consideration by the Madras Department of Agriculture. An account of this and some other palm diseases has been contributed for publication in the Agricultural Journal of India.

From time to time suggestions have been made for checking outbreaks of insect pests by the dissemination of disease amongst them. Several cases are known of the occurrence of fungus parasites in harmful insects. One of the most noted of these is the locust fungus, which has been stated to destroy locusts in South Africa. A series of tests with this fungus was carried out, in conjunction with the Imperial Entomologist, on the Bombay and North-Western locusts, and some species of grasshoppers destructive to crops. In no case did any benefit result, and though in the case of the North-Western migratory locust there were some evidences of infection, still even here the method is clearly not of practical value in the field. A departmental report has been submitted.

Attempts have also been made to check the green bug of coffee in Southern India, by means of a fungus which attacks various scale insects. The parasite was imported from the United States, by the United Planters' Association of Southern India; some was applied directly to the infested coffee bushes, while some was sent to Pusa for culture. It was not found possible to get satisfactory cultures, and the attempt at direct inoculation also failed. As the parasite is not known to attack the coffee bugs in any country, this failure was not unexpected.

A commencement has been made at Pusa in the study of the fungi concerned in breaking down organic matter in the soil. A number of the chief soil species were isolated and determined.

List of publications dealing with Indian Agricultural Botany in 1905-06.

BOARD OF AGRICULTURE IN INDIA.	Proceedings for 1906.
BARBER, C. A. . .	The Samalkota Sugarcane Farm. *The Agric. Journ. of India*, i, part 1, 1906.
BARBER, C. A. . . .	The Production of early maturing Canes. *The Agric. Journ. of India*, i, part 3, 1906.
BENSON, C., & SUBHA, C. K.	The Great Millet or Sorghum in Madras. *Depart. of Agric. Madras*, iii, Bulletin No. 55, 1906.
BUTLER, E. J. . .	The Wilt Disease of Pigeon-pea and Pepper. *The Agric. Journ. of India*, i, part 1, 1906.
BUTLER, E. J. . .	The bearing of Mendelism on the susceptibility of Wheat to Rust. *The Journ. of Agric. Science*, i, part 3, 1905, Cambridge.
BUTLER, E. J. . .	Fungus Diseases of Sugarcane in Bengal. *Mem. Depart. of Agric. in India*, Bot. Series, i, No. 3, 1906.
BUTLER, E. J., & HAYMAN, J. M.	Indian Wheat Rust. *Mem. Depart. of Agric. in India*, Bot. Series, i, No. 2, 1906.
FLETCHER, F. . .	Phœnix dactylifera *Linn.*, the Date Palm. *The Agric. Ledger*, No. 1, 1906.
GAMMIE, G. A. . .	The Indian Cottons.
MANN, H. H. . . .	The Blister Blight of Tea. *Indian Tea Assoc. Bull.*, No. 3, 1906.
WATT, SIR G. . .	Sorghum vulgare *Pers.*, the Great Millet or Juar in India. *The Agric. Ledger*, No. 6, of 1905.

Numerous minor notes in the Agricultural Journal in India.

AGRICULTURAL BOTANY

BY

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Foods.—The botanical study of the cereals mentioned in the last report—wheat, juar, rice and barley—has not yet reached the stage of publication but is still in progress. No publications of botanical importance have been issued in connection with Indian cereals during the year. Agricultural Ledgers on the races of juar and on the rice, *Oryza coarctata*, are promised shortly by Mr. Burkill, Reporter on Economic Products. Mr. Howard, Imperial Economic Botanist, has a large monograph of Indian wheats under preparation. This is based on representative collections grown and isolated at Pusa and Lyallpur, as typifying the Eastern and Western Indo-Gangetic areas, extended by field observations in other tracts. The classification of Indian wheats is completed. A number of successful crosses have been obtained at Pusa and Lyallpur, and wheat-breeding work is proceeding at these stations on Mendelian lines. The botanical enquiry into Indian barleys has been made over by the Reporter on Economic Products to Mr. Howard, who has commenced the preliminary work at Pusa.

Mr. Barber has continued his work on sugarcane in South India. Special attention has been paid to the origin of sugarcane varieties. An account of their origin by " sporting " or bud-variation, in certain cases observed at the Samalkota Farm, has been published. Some of the sports have proved of exceptional quality and have been segregated and cultivated. They have originated only from striped canes, and this is held to indicate that the striped varieties are in reality hybrids between two canes of different colours. At the last meeting of the Board of Agriculture the whole question of the improvement of the Indian sugarcane industry was discussed. A number of papers on the

subject was laid before the Board, and from these it may be gathered that, although the agricultural characters of Indian sugarcanes have been investigated in some provinces, notably by Khan Bahadur S. M. Hadi in the United Provinces, no real botanical work with them has yet been attempted in this country. Though seedling canes have actually been raised, they have never reached the experimental stage, and this immensely important line of work has yet to be undertaken in India. Individual selection for yield and quality of juice is another promising direction awaiting attention. The ground has, however, been cleared for future work, as soon as the botanical staff becomes strong enough to undertake it.

The reports on Indian yams, caraways and Burmese pulses, referred to in last year's report, are still in preparation ; enquiries are also being continued regarding chillies, pan (Piper Betel), plantains and kessary (*Lathyrus sativus*) by the Reporter on Economic Products.

Mr. Burkill has published a Ledger on Goa beans (*Psophocarpus tetragonolobus*), which gives the history, distribution and characters of the pulse in India. Another Ledger has been written by Mr. D. Hooper on the food value and uses of the root of *Costus speciosus*. The identity of the common root of the Calcutta market called " Singapuri kesur " was determined by Mr. Burkill, who has found it to be the root of *Eleochairs tuberosa*, the Chinese " Pe-tsi " or " Ma-tai."

A series of experiments designed to throw light on the behaviour of Indian fruit trees under different conditions and treatment has been initiated by Mr. Howard at Pusa. A first report on these has been published, giving details of the main lines of work.

Fibres.—A large and important work on the cottons of the world by Sir G. Watt is announced. The memoir on Indian cottons by Professor Gammie, referred to in last year's report, is now in the Press. Mr. Fletcher, Deputy Director of Agriculture, Bombay, has published a preliminary note on Bombay cottons. From this it appears that considerable progress has recently been made in introducing exotics, especially Egyptian cotton, in Sind. Sea Island cotton of good quality was grown at Karachi in 1906. Tree cottons of the " rough Peruvian " (? *G. peruvianum*) and Bourbon (? *G. barbadense*) types are being grown in the Karnatak and Ahmedabad-Kaira tracts, respectively. A large collection of tree cottons is maintained at Poona for botanical investigation by Professor Gammie, who has prepared a preliminary

classification of the main types. Mr. Fletcher records that at least one extremely promising hybrid cotton has been reared on the Surat Farm, and remarks that this hybrid, No. 1027 A, will, if it preserves its good qualities, be worth many times more than the whole expenditure on the Surat Farm since its commencement. A memoir on the cotton known as *Gossypium obtusifolium* Roxb. has been published by Mr. Burkill, and the same author has furnished a note on the pollination of the cotton plant, which tends to confirm the conclusion previously reached by Professor Gammie, that cross-fertilization and natural hybridization are rare in cultivated members of this genus.

A review of the Indian Agaves has been published by Mr. J. R. Drummond and Lieutenant-Colonel Prain, as Agricultural Ledger No. 7 of 1906. The more important features of this work, from our point of view, are the following. *Agave americana* is apparently not a naturalized plant in any part of India, but is merely grown in gardens as an ornamental plant. It disappears therefore as a name for any plant yielding commercial fibre in India. Where *A. americana* has been spoken of in previous Indian literature some other species is almost always intended. This is often *A. Cantala*, which gives good fibre and is largely exported, mixed with others, as "Bombay aloe fibre." All told ten species have been separated in the course of this enquiry, of which six are identified and the remaining four are not at present identifiable owing, in great measure, to the extraordinarily confused condition of the literature on the subject. Besides *A. Cantala* three other species are of economic importance in India according to present knowledge, *viz.*:—*A. sisalana*, a comparatively recent introduction, *A. Wightii*, which has the disadvantage of being short-leaved, and an unidentified species called temporarily by the authors *A.* "*species F.*" Three, *A. americana*, *A. decipiens* and *A.* "*species C.*," are only known in India as ornamental plants or in herbaria as dried specimens. One, *A.* "*species A.*," has only been obtained during the enquiry from Burma, but is probably cultivated at the Saharanpur Botanical Garden. Of the remaining two nothing is really known about the fibre, but *A.* "*species H.*" is the finest plant of the naturalized species, with leaves 7 or 8 feet long, is widely distributed and, it is believed, would repay careful investigation; while *A. Vera Cruz* is less likely to be profitable. Further, two species of plants yielding Mauritius hemp occur in India, where previously but one (commonly called *Furcræa gigantea*) was

supposed to exist. Owing to the difficulty of determining which of these was referred to by the older botanists, the authors have contented themselves with calling them species 1 and 2.

Mr. Burkill is still engaged in his botanical study of the races of jute. A first outcome is a "Note on the pollination of *Corchorus* in Bengal and Assam." Contrary to a previous assertion, insects were found freely visiting the flowers. Hybridization between the different races is, however, not a frequent result. Part of the jute work is in collaboration with Mr. R. S. Finlow, Fibre Expert to the Government of Eastern Bengal and Assam. It is in continuation of the investigation started by the Sub-Committee of this Board in 1904 and is preliminary to further work involving selection and possibly hybridization. An account of what has been done so far is now in the press. Mr. Finlow has in conjunction with Mr. C. Bergtheil, Imperial Bacteriologist, carried out a series of experiments with seeds of several fibre-yielding jungle plants, which show the character of delayed germination. These have all responded to the sulphuric acid treatment for hardcoated seeds referred to in last year's report, and again below, under "dyes."

Experiments with Sunne hemp (*Crotalaria juncea*) were continued at the Royal Botanic Garden, Calcutta. The fibre grown from races received from different parts of India has been extracted and sent to London for valuation.

The fibre garden at Pusa under Mr. Howard has been brought into working order and experiments with a number of species of fibre plants have been commenced.

Oils, dyes, drugs, etc.—An important monograph on the oil grasses of India and Ceylon by Dr. O. Stapf of Kew was recently published in the Kew Bulletin. Twelve oil-yielding species are described, all but one occurring in India. Of these, the important commercial species in India are the following:—*Cymbopogon flexuosus*, the source of Cochin or Malabar Lemon-grass oil; *C. citratus*, the source of Lemon-grass oil proper, inferior to the preceding but widely cultivated in Indian gardens; *C. Martini*, the source of the Rusá oil of Khandesh and the Central Provinces; and *Veteveria zizanioides* (*Andropogon muricatus* Retz), the "khas khas" grass, the roots of which are extensively used in the preparation of perfumes in India and are exported to Europe for extraction of the oil. The products of these grasses are being investigated by the Indian Museum, in conjunction with Messrs. Schimmel

& Co., of Miltitz near Leipzig. The enquiry into possible sources of camphor from Burmese species of *Cinuamomum*, mentioned last year is being prosecuted by the Reporter on Economic Products.

Messrs. Bergtheil and Day contributed a paper to the Annals of Botany on the cause of "hardness" in the seed coats of *Indigofera* arrecta. As mentioned in last year's report, the difficulty encountered in germinating the seed of this species, the Java or Natal indigo which is so rapidly extending in cultivation in Behar, was overcome by a method elaborated by Mr. Bergtheil, which consists in treating the seed with strong sulphuric acid. The cause of delayed germination is attributed in the present paper to the existence of an outer, very thin covering of a substance resistant to water. The exact nature of this substance was not determined, but it appears to be a body intermediate between cellulose and cuticle. Sulphuric acid swells it and makes it permeable to water, while the older method of scarifying the seed ruptures it. Further investigations have been carried out by Mr. Bergtheil at the Sirsiah Indigo Research Station on the superiority of first crop over rattoon plants for seed purposes, the best method of preserving the vitality of Java indigo seed, the indigotin content of various species of *Indigofera* and preliminary work in isolating the chief types of the Sumatrana plant, with a view to selection. Trials of soil inoculation with the nodule bacilli of the legume family at this station have confirmed with indigo the results already obtained in other parts of India with other crops, that no benefit results from the practice with common Indian crops.

Mr. Burkill has commenced a botanical examination of Nepalese Aconites in connection with Professor Dunstan's work on Indian sources of the drug. Mr. Howard is engaged on a botanical study of Indian tobaccos, including an investigation of the biology of the flower and the extent to which variation takes place.

Miscellaneous.—An account of acclimatization work carried out at the Saharanpur Botanical Garden, compiled by the late Mr. W. Gollan, was published as a Bulletin of the Department of Agriculture, United Provinces. It contains a mass of information regarding the results of trials of a large number of exotic plants of economic value. Mr. F. G. Sly, Officiating Inspector General of Agriculture in India, contributed a history of the attempts to establish exotic drought-resisting plants in India, to the Agricultural Journal of India. The conclu-

sion arrived at after a survey of the various trials is in agreement with the opinion expressed by Lieutenant-Colonal Prain, recently Director of the Botanical Survey of India, that there is much more promise in the extension of indigenous salt bushes and other plants than in trials of exotics.

Mr. Fletcher, recently Deputy Director of Agriculture, Bombay, has carried out a series of experiments tending to show that the roots of plants excrete an auto-toxic substance during growth. A memoir giving details of the work is in the Press.

Mycology and plant pathology.—An account of the "red rust" of tea caused by the interesting alga, *Cephaleuros virescens*, was published by Dr. H. Mann and Mr. C. M. Hutchinson, of the Scientific Department of the Indian Tea Association. This is a technical account of the authors' work, the chief practical results of which have already been published.

The first part of a series entitled "Fungi Indiæ Orientalis" has been issued by Messrs. H. and P. Sydow of Berlin in conjunction with the writer. This contains technical descriptions with notes of 143 species of parasitic rusts and smuts, of which one genus and 42 species are new to science. A second instalment, completing these groups as far as they are represented in the Pusa Herbarium and including the *Phycomycetes*, in all about 200 species, has been worked out and will shortly be published. This is the first attempt at a systematic account on a large scale of the Indian fungus flora. The monograph on the *Pathiaceæ* referred to last year has been published. The chief species of economic importance in India is *Pythium palmivorum*, a destructive parasite of palms. A more popular account of the disease caused by this fungus and some other palm diseases was published in the "Agricultural Journal of India." Operations in its prevention are in progress in the Godavari Delta, under a special establishment sanctioned by the Government of Madras.

A curious group of cereal diseases, producing floral malformations and sterility in several important crops, was studied and its cause ascertained to be the parasitic Phycomycete, *Sclerospora graminicola*. An account of these diseases, which may at any time become epidemic, was published. Attempts to raise wilt-resisting varieties of pigeon-pea are in progress at Poona, and are promising well. Treatment of the ticca disease of ground-nut by spraying and steeping, at the same

locality, has proved unsatisfactory, and the only hope of reducing the losses caused by this disease appears to be the raising of early maturing and resistant varieties. Work is well advanced on the group of wilt diseases in India caused by *Neocosmospora vasinfecta* and affecting cotton, pigeon-pea, gram, indigo and other crops. The full investigation will take some years to complete. Another troublesome investigation, as yet incomplete, is that of an orange disease prevalent in Sylhet and Burma. Work with sugarcane diseases, wheat and other rusts, and a number of other crop diseases, was continued by the writer.

The trials of the South African Locust fungus carried out by the writer in conjunction with the Imperial Entomologist were completed and a report issued. This much-vaunted method of destroying locusts has proved absolutely useless. Recent work in South Africa itself gives a sufficient reason for this. The fungus distributed by the South African authorities (and which was employed in India) has been ascertained to be quite different to the actual locust parasite, and is probably an accidental contamination from the first prepared tubes. This fact escaped detection until now, owing to the absence of any mycologist on the spot until recently. It is doubtful if the true locust parasite in the Transvaal can be artificially cultivated, but attempts are being made on the spot, and, if successful, the work can be repeated under better auspices in India.

List of publications dealing with Indian Agricultural Botany in 1906-07.

BOARD OF AGRICULTURE IN INDIA.	Proceedings for 1907.
BARBER, C. A. . .	The origin of new sugarcanes by "bud-variation." *Agric. Jour. of India*, Vol. I, pt. 4, October 1906.
BERGTHEIL, C. . . .	Report of the Indigo Research Station, Sirsiah, for the year 1906-07.
BERGTHEIL, C., AND D. L. DAY	On the cause of "Hardness" in the seeds of Indigofera arrecta. *Annals of Botany*, XXI, 57, 1907.

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BUTLER, E. J. . . Some Diseases of Palms. *Agric. Jour. of India*, Vol. I, pt. 4, October 1906.

BUTLER, E. J. . . An account of the genus Pythium and some Chytridiaceæ. *Mem., Dept. of Agric. in India*, Bot. Series, Vol. i, No. 5, February 1907.

BUTLER, E. J. . . Some Diseases of Cereals caused by Sclerospora graminicola. *Mem., Dept. of Agric. in India*, Vol. ii, No. 1, March 1907.

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HOOPER, D. . . Costus speciosus. The uses and value of the root of Costus speciosus as a food stuff. *Agric. Ledger*, No. 2, of 1906.

HOWARD, A. . . First Report on the fruit experiments at Pusa. *Bull. of Agric., Research Institute, Pusa*, No. 4, 1907.

MANN, H., AND C. M. HUTCHINSON. Cephaleuros virescens, Kunze, the "red rust" of Tea. *Mem., Dept. of Agric. in India*, Vol. i, No. 6, April 1907.

SLY, F. G. . . . The trial of Exotic drought-resisting plants in India. *Agric. Jour. of India*, Vol. ii, pt. 2, April 1907.

STAPF, OTTO. . . The Oil-grasses of India and Ceylon. *Kew Bull.*, 1906, No. 8.

SYDOW, H. AND P., AND E. J. BUTLER. Fungi Indiæ Orientalis, pt. i. *Annales Mycologici*, Vol. iv, No. 5, 1906.

G. I. G. P. O.—No. 15 S. B. S. A.—50—J. A.

MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Enquiries into cocoanut and other palm diseases in South India were ntinued. The Government of Madras provided the grants necessary to rry on the campaign against the Godavari palm disease for a second ar. A visit was paid to Travancore to investigate a wide-spread coanut disease there and the results published in a report issued in arch, 1908.

The general survey of Indian parasitic fungi was carried a step ther, the groups dealt with being the rusts, smuts and false mildews in llaboration with Messrs. H. and P. Sydow of Berlin, and the true ldews with Mr. Salmon of Wye College.

A tour was made in Burma in January, 1908, to report on the diseases crops in that Province and to study orange disease in Amherst District. e cause of the latter has not yet been definitely ascertained.

The study of wilt diseases of various crops, sugarcane diseases, linseed st and diseases of citrus fruits was continued.

Publications.

BUTLER, E. J. Report on Cocoanut disease in Travancore. *Bulletins of the Agricultural Research Institute. Pusa, No. 9, March 1908.*

SALMON, E. S. Notes on some species of Erysiphaceæ from India. *Annales Mycologici, Vol. V, No. 6, December 1907.*

SYDOW, H. and P. & E. J. BUTLER.—Fungi Indiæ Orientalis, Part II *Annales Mycologici, Vol. V, No. 6, December 1907.*

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Mr. MacRae, Officiating Imperial Mycologist, investigated a severe outbreak of blister-blight of tea in Darjeeling District. The disease has been known for many years, but was confined to North-East Assam, where it occasionally caused serious loss. The climatic conditions of Darjeeling appear to be more favourable to the parasite, and it spread with great rapidity after its first introduction in 1908. The life-history of the fungus (*Exobasidium vexans*) which causes it was fully studied by Mr. MacRae and experiments carried out to ascertain the best methods of checking it. The preliminary results were published by the Darjeeling Planters' Association in 1909, and fuller accounts have appeared in the Agricultural Journal of India, and as a Bulletin of the Pusa Institute in 1910.

The campaign against bud-rot of Palms in Madras Presidency was continued. Extension in the Godavari District has been checked but has progressed in Kistna, where the operations were started late. An account of the disease and of the results of the efforts made to stamp it out, was written by the Imperial Mycologist, and has appeared since the close of the period covered by this report

A serious disease of Areca palms, known locally as *Koleroga*, was investigated by Dr. L. Coleman, Mycologist and Entomologist to the Mysore Government. Spraying experiments carried out in 1909, demonstrated the possibility of saving a great portion of the nuts at a low cost. With the exception of spraying for potato-blight which is practised to a limited extent in the Khasi Hills, this is probably the first successful application of this method of checking fungus diseases made in India on native crops. A full account of the disease and of the remedial measures adopted has since been published as a Bulletin of the Mysore Department of Agriculture.

The results of several years' investigation of the wilt disease of *tur* (pigeon-pea) were published by the writer early in the year. Incidentally it was shown that the fungus *Neocosmospora vasinfecta*, to which many similar diseases have been attributed is, at least in India, a harmless soil saprophyte.

Mr. MacRae visited Rangpur, Eastern Bengal, twice in connection with an enquiry into the cause and treatment of ginger-rot, a disease which the writer had found also to be prevalent in Gujarat. The fungus (*Pythium gracile*) which was noted as the probable cause of the disease in Gujarat was also found in the diseased plants at Rangpur. Attempts to cultivate it failed, so that absolute proof of its parasitism has not been obtained. An account of the disease with a description of the methods of treatment which have given successful results on the Burirhat Farm, is in the press.

Experiments in spraying potatoes with Bordeaux mixture as a protection against potato-blight were continued at the Upper Shillong Agricultural Station, and the results are given in the Annual Report of the Agricultural Stations in Eastern Bengal and Assam for 1908-09. The profit resulting from spraying was less than in previous years, but still amply justifies the practice. Demonstrations were carried out on an extensive scale on cultivators' holdings in the Khasi Hills with very satisfactory results, and a separate report on them is promised in the near future.

Mr. Burns, Economic Botanist, Bombay, is continuing his work on wheat rust at several of the Bombay stations, particularly with a view to determining the conditions by which the disease is influenced. Some notes on the subject are given in the Report of the Ganeshkhind Botanical Station for 1908-09 and a fuller account has been submitted for publication. Experiments in treating jowar seed to prevent smut were made at the Dharwar Agricultural Station. Steeping in 2 per cent. copper sulphate for 10 minutes was found to prevent the disease entirely. Attempts to obtain a wilt-resisting variety of *tur* are being made at Kirkee and Dharwar.

Mr. Clouston, Deputy Director of Agriculture, Southern Circle, Central Provinces, has continued to test cottons, with regard to their comparative susceptibility to wilt, at Akola. *Buri* cotton has proved immune to this disease so far and is being introduced on wilt-affected lands. The use of copper sulphate as a steep for jowar seed was demonstrated widely in the Central Provinces where smut causes great losses. The practice is said to be extending amongst the cultivators. Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, is endeavouring by hybridisation and selection to obtain a rust-resistant wheat at Hoshangabad and is also trying to get a wilt-resisting *tur*.

At the Samalkota Station in Madras the work of resuscitating sugarcane cultivation in the Godavari Delta where it was dying out from the ravages of red-rot, was continued. The success obtained so far has been considerable. In the Report of the Station for 1908-09 Mr. R. C. Wood,

eputy Director of Agriculture, Northern Circle, Madras, summarises the actical results already obtained, but calls attention to a disheartening out-eak of disease on the Farm in the previous year. It has since been scertained by the writer and Mr. A. Hafiz Khan that this was probably ot red-rot, but a new root disease which is under study.

Mr. MacRae visited the Wynaad in November 1909, in company with Ir. Anstead, Planting Expert to the South Indian Planters' Association, to ake further enquiries into the pepper-vine disease of Malabar. Reports n the tour are given in the Planters' Chronicle, Vol. IV, No. 12, and a cheme of experimental measures for its control, drawn up jointly by the wo officers, in Vol. V, No. 2 of the same journal.

Mr. Burns has contributed short notes on diseases of mango trees to the Poona Agricultural College Magazine.

The cocoanut-palm disease in Travancore continues to occupy the atten-ion of the Agricultural Department of that State. In the Annual Report f the Department for 1908-09, Mr. N. K. Pillai outlines the scheme of xperiments in the treatment of the disease which he has started, and gives urther notes on the area affected and prospects of successful treatment.

Numerous short notes on fungus diseases of rubber, tea, coffee, pepper nd other plants have been contributed to the Planters' Chronicle by Mr. Anstead.

The operations carried out in Coorg to limit the spread of spike disease f Sandal are reviewed by Mr. C. McCarthy, Deputy Conservator of Forests, in the Progress Report on Forest Administration in Coorg for 1908-09. Though the extension of the disease into the unaffected northern portion of the province has been checked, there is no appreciable lessening of its severity within the affected area.

An account of a suspected parasite of several important forest trees and palms was contributed by the writer to the Indian Forester. The fungus (*Fomes lucidus*) is a common tropical and sub-tropical species, but has hitherto been generally supposed to be harmless.

An important contribution to the little studied bacterial diseases of plants was published by Dr. Coleman in the Mysore Agricultural Bulletins. The disease is one which affects potatoes throughout Peninsular India and is known as "ring" or "*bangadi*" disease. The bacterium which causes it was isolated and successful inoculations obtained not only on potatoes but also on brinjals and tomatoes. Suggestions for checking its ravages are given.

List of Publications.

ANSTEAD, R. . . Numerous notes on fungus diseases of rubber, tea, coffee, pepper, etc. in *Planters' Chronicle, iv, v, 1909-10.*

BURNS, W. . . Notes on wheat rust in *Ann. Rep. of the Ganeshkhind Bot. Stat. for 1908-09, Bombay, 1909.*

BURNS, W. . . "A note on red rust of the Mango tree" and "Observations on diseases of the Mango tree" (*Poona Agri. Coll. Mag., i, Nos. 1 and 2, 1909-10.*)

BUTLER, E. J. . . *Fomes lucidus* (Leys) Fr., a suspected parasite. (*Ind. For., xxxvi, Sept. 1909.*)

BUTLER, E. J. . . The wilt disease of pigeon-pea and the parasitism of *Neocosmospora vasinfecta.* Smith. (*Mem. Dept. of Agric. in India, Bot. Ser., ii, No. 9, 1910.*)

CLOUSTON, D. . . in *Report on the Agricultural Stations in the Central Provinces for the year 1908-09, Nagpur, 1909.*

COLEMAN, L. C. . The Ring disease of Potatoes (*Bull. No. 1, Mycol. Ser., Dept. of Agric., Mysore State, 1909.*)

EVANS, G. . . in *Report on the Agricultural Stations in the Central Provinces for the year 1908-09, Nagpur, 1909.*

MCCARTHY, C. D.'A. Spike disease in Sandal (*Progress Report on Forest Administration in Coorg for 1908-09, Bangalore, 1910.*)

MACRAE, W. . . The Outbreak of Blister-blight on tea in the Darjeeling District in 1908-1909 (*Ag. Jour. Ind., v, 126, 1910.*)

MACRAE, W. . . Report on the Outbreak of Blister-blight on tea in the Darjeeling District in 1908-09 (*Bull. A. R. I. Pusa, No. 18, 1910.*)

MACRAE, W. . . Pepper-Vine disease (*Planters' Chronicle, iv, 352 and v, 13, 1909-10.*)

MAIN, T. F. . . in *Annual Report on the Experimental work of the Dharwar Agricultural Station for 1908-09, Bombay, 1909.*

PILLAI, N. K. . Cocoanut palm disease in *Annual Report of the Department of Agriculture, Travancore, for the year 1908-09, Trivandrum, 1909.*

WOOD, R. C. . . in *Scientific Report of the Samalkota Agricultural Station for 1908-09, Madras, 1909.*

MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

I.—Plant Pathology.

Palm diseases.—Two papers of considerable length on the diseases of palms appeared during the year. Dr. L. C. Coleman published an account of the Areca palm disease known as *koleroga*, in the Bulletins of the Agricultural Department, Mysore. The fungus which causes this disease was first seen by the writer in 1903, and identified, in a paper published in 1907, as *Phytophthora* (?) *omnivora* de Bary. Dr. Coleman, while still including it in the probably composite species, *Phytophthora omnivora*, makes a distinct variety, *Arecæ*, for it. Its hosts are *Areca Catechu*, *Cereus formosus*, *Clarkia elegans*, *Schizanthus wisetonensis*, *Oenothera biennis*, *Salpiglossus variabilis*, *Solanum melongena* and *Lycopersicum esculentum*. A closely allied species occurs on Cacao in Ceylon and other parts of the tropics, and is capable of attacking nearly all the above hosts. As a result of a thorough comparison of the two forms in artificial cultures, Dr. Coleman concluded that they are distinct species and named the Cacao fungus *Phytophthora Theobromæ*. It was, however, named *Phytophthora Faberi* by Maublanc, prior to the publication of Dr. Coleman's paper, and the latter name must stand. A very full account is given by the author of the characters and biology of the Areca parasite and of the remedial measures carried out by him to reduce the losses, estimated at 3 to 4 lakhs of rupees annually, caused by the disease in Mysore. A single spraying with Bordeaux mixture, applied just before the break of the monsoon, was found to be effective in saving a large proportion of the nuts. The cost is well within the means of the arecanut growers. Further experiments are being carried out to test the relative efficiency of various methods of spraying. An abridgment of the bulletin was published in the *Annales Mycologici*.

The bud-rot of palms in Madras Presidency was described by the writer in a memoir published early in the year. The disease has been under observation since 1905, and an extensive campaign to check its spread and stamp it out was started by the writer, with funds and assistance provided by the Madras Government, in 1907. Since 1910

the work has been in the hands of the recently appointed Madras Mycologist, Mr. McRae. The memoir includes a description of the area affected by the disease, an account of its first appearance and spread, the species of palms affected (including palmyra, cocoanut and areca), a full description of the fungus, *Pythium palmivorum*, which is its cause, and a discussion of the operations to check it carried out by Government. The conclusions arrived at are that these operations have been entirely successful in limiting the disease in Godavari district to the area previously infected; it is hoped that they will prove equally effective in Kistna district, where they were started late. This alone should fully justify their cost. At the time the memoir was written it was not easy to determine what effect the previous work had had in reducing the intensity of the disease within the infected area, but further records during the past year tend to show that the steady removal of infected trees is bearing fruit in a diminution of the number of new infections. The operations are being continued and it is anticipated that if the disease can be kept confined within its present limits, it will eventually be possible to stamp it out completely.

Ginger disease.—An account of the soft rot of ginger was written by Mr. McRae for the Agricultural Journal of India. This disease is prevalent in Eastern Bengal, Gujarat and probably elsewhere. In Rangpur the loss in damp soils is 10 to 15 per cent. of the crop; in bad years almost the whole may be lost. The cause appears to be the attack of a fungus (*Pythium gracile*) on the rhizomes and base of the plant. As a result of experiments carried out at Burirhat farm in 1908-09, Mr. McRae was in a position to recommend effective measures for checking the disease.

Turmeric disease.—The writer described a leaf disease of turmeric, found all over Northern India, in the *Annales Mycologici*. It is caused by a previously undescribed species of *Taphrina* which, while not very destructive, is probably responsible for a greater reduction of the yield than the cultivators themselves suspect. No treatment can be recommended as yet.

Tea diseases.— A parasite of the tea bush, *Læstadia Theæ*, found in Java some 12 years ago but not previously recorded in India, was reported from the Dooars in 1910. It causes a leaf disease known as copper-blight, which spreads with great rapidity under suitable weather conditions. A note describing its characters was written by Mr. Shaw for the *Agricultural Journal*. The writer investigated a disease of tea seed, known for many years in Assam to cause considerable loss in

certain tea-seed gardens. Acting on a suggestion made by the officers of the Scientific Department of the Indian Tea Association, a good deal of evidence was obtained indicating that the disease is due to the tea seed bug, *Pœcilocoris latus*. This insect punctures the seed and sucks the juices. Through the opening thus made fungi are able to enter, and the subsequent injury to the seed is due to the growth of one or other of several species of rot-producing fungi at the expense of the seed tissues. It has long been a pathological puzzle how the fungi which are often found within hard-shelled seeds, such as the walnut, have been able to effect an entry; possibly the explanation in these cases will be found to be similar to that of the tea-seed fungus. The Indian Tea Association are issuing a pamphlet on the subject. As a result of the extension of blister-blight in India, mentioned in last year's report, some countries have insisted on the disinfection of all Indian tea seed exported to them. The writer was asked to advise on the subject and recommended steeping in formalin, which has been adopted. It is a matter for congratulation that the Indian Tea Association have decided to strengthen their Scientific Department by the addition of a Mycologist, as the fungus diseases of tea are growing in importance.

Forest tree diseases.—As usual the Forest Department referred a certain number of diseases of trees for investigation in the Mycological Laboratory at Pusa. The chief result was a paper on the root infection of the blue pine by *Trametes Pini*, a fungus which is causing considerable damage in the Simla Hill forests, by A. Hafiz Khan. This fungus was hitherto believed to be able to attack trees through above ground wounds only. A second method of infection was shown to occur below ground, through roots of diseased trees coming into contact with those of healthy ones. Mr. Anstead, Planting Expert to the United Planters' Association of Southern India, has described in the *Planters' Chronicle* the results of experiments conducted in Cochin to prevent the attacks of "pink disease" of rubber trees, caused by the fungus *Corticium javanicum*. Over two hundred thousand Para trees were treated with Bordeaux mixture, with most encouraging results. One estate reported that the disease had been diminished by 75 per cent. and the Manager believes that if every tree were done properly the disease would disappear. The mixture, made up of 6 lbs. copper sulphate, 4 lbs. quicklime and 45 gallons water, with a locally prepared paste or resin or jaggery added to improve its adhesive properties, is brushed on the trees near the forks and over wounds. The cost is very little, only Re. 1 to Rs. 2 per acre. As this is by far the worst disease of rubber trees in South India such results are very gratifying.

Fruit diseases.—The principal work on fruit diseases published during the year was Mr. Burns' bulletin on grape-vine mildew in Bombay Presidency. In this the occurrence of the disease at Nasik and near Poona is described and the results of experiments in its control, carried on under Mr. Burns' direction by his assistants and the owners of the vineyards, are given. Spraying with Bordeaux mixture, to which soft soap was added as an adhesive, was found to reduce the damage considerably. The 6-4-50 formula was used, except when actually spraying the bunches of fruit, when half strength was employed. The results were satisfactory when the work was carefully carried out between Mid-December and Mid-February, the critical period of the year for the disease in this district. Mr. Basu, Assistant Professor of Mycology at the Bengal Agricultural College, investigated a disease of plantains at Chinsurah, and wrote a note describing it in the *Bengal Quarterly Agricultural Journal*. The disease appears to be caused by a species of *Fusarium*, but further work is necessary to establish this.

Miscellaneous.—Experiments carried out at Pusa, and independently by the Mycological Assistant of the Bombay Department of Agriculture at Poona, have demonstrated that the fungus which causes pigeon-pea wilt produces its spores freely on the stems of diseased plants. Hence in addition to soil infection from previously diseased crops, air-borne infection is also possible. Work on sugarcane diseases is in progress at Pusa, Sabour and Poona, but has not yet yielded results to justify publication. Mr. Shaw of Pusa has a large investigation in hand on the root-rot of a number of cultivated plants, caused by a species of *Rhizoctonia*. The results are not yet ripe for publication. Most of the experimental and demonstration work in treating plant diseases, mentioned in last year's report as being in progress at various farms of the Provincial Departments of Agriculture, has been continued.

For some years black spore-like bodies have been observed as impurities in samples of "Indian" rice flour, examined in the Laboratory of Agricultural Chemistry of the Royal Agricultural College, Berlin. Specimens of these sent to the writer enabled him to identify them as the spores of the rice bunt, *Tilletia horrida*. This fungus was hitherto known to occur only in Japan and the United States; it appeared unlikely that its presence in India proper could have escaped detection; the Berlin authorities were therefore asked to ascertain the exact origin of the rice containing the impurity. The results of the investigation were published by Herr P. Filter in the *Centralblatt für Bakteriologie*

recently. The rice containing this fungus was found to have been imported from Siam, Moulmein and Bassein. We may conclude, therefore, that rice bunt occurs in Siam and Burma and is either restricted to these countries by climatic conditions or, more probably, is spreading from a centre in Eastern Asia and will eventually reach India proper.

II.—Systematic Mycology.

A new genus of the *Uredinaceæ* was described by the writer in the *Annales Mycologici*. It was collected on *Olea dioica* in the Deccan and is of considerable taxonomic interest.

A collection of fungi, chiefly *Agaricaceæ*, made by the Rev. Father Blatter in Bombay and Dehra Dun, was described by the Rev. F. Theissen, S.J., in the *Annales Mycologici*. Two new species of the Uredinaceous genus *Phakopsora* were described by Dr. P. Dietel and three new species of smuts by Herren H. and P. Sydow from Indian material supplied by the writer. One of the latter is of economic interest as a parasite of *Panicum frumentaceum*, one of the cultivated millets of India. Notes on the rare genus *Pucciniostele*, based on Himalayan specimens sent by the writer, were included in a paper by Dr. P. Dietel on Japanese *Uredinaceæ*. Mr. Massee has described two new species of fungi which attack wood and also a new species of edible truffle from the United Provinces.

The large collections of Ascomycetous fungi in the Pusa Herbarium were worked through by the writer; annotated lists, prepared in collaboration with Herren H. and P. Sydow of Berlin, are in the press. A description of a remarkable aquatic fungus found at Pusa will also appear shortly.

List of Publications.

Ansteal, R. . . Pink disease of Para Rubber and Bordeaux Mixture. (*Planters' Chronicle, v, No. 18, 1910, and vi, No. 8, 1911.*)

Basu, S. K. . . Report on Banana Disease of Chinsurah. (*Quarterly Journal, Dept. of Agric., Bengal, iv, No. 4, p. 196, 1911.*)

Burns, W. . . First Experiments in treatment of Grape Vine Mildew in Bombay Presidency. (*Dept. of Agric., Bombay, Bull. No. 36, 1910.*)

BUTLER, E. J. . The Bud-rot of Palms in India. (*Mem. Dept. of Agric. in India, Bot. Ser., iii, No. 5, 1910.*)

BUTLER, E. J. . A new genus of the *Uredinaceæ*. (*Annales Mycologici, viii, p. 444, 1910.*)

BUTLER, E. J. . The leaf spot of Turmeric (*Taphrina maculans* sp. nov). (*Annales Mycologici, ix, p. 36, 1911.*)

COLEMAN, L. C. . Diseases of the Areca palm: I. Koleroga. (*Bull. No. II, Mycol. Ser., Dept. of Agric., Mysore State, 1910, and Annales Mycologici, viii, p. 591, 1910.*)

DIETEL, P. . . Uredineen aus Japan: III. (*Annales Mycologici, viii, p. 304, 1910.*)

DIETEL, P. . . Zwei neue Arten der Gattung Phakopsora. (*Annales Mycologici, viii, p. 469, 1910.*)

FILTER, P. . . Ueber das Vorkommen von Tilletia horrida Takahashi in Reisfuttermehlen. (*Centralbl. für Bakter. Parasitenk. u. Infektionskr., 2nd Ab., xxix, p. 342, 1911.*)

HAFIZ KHAN, A. . Root infection of *Trametes Pini*. (*Ind. For., Oct. 1910.*)

MCRAE, W. . . Soft rot of Ginger in the Rangpur District, Eastern Bengal. (*Agric. Journ. Ind., vi, p. 139, 1911.*)

MASSEE, G. . . Fungi exotici. (*Kew Bull., 1910, No. 7, p. 249.*)

SHAW, F. J. F. . Copper blight of Tea. (*Agric. Journ. Ind., vi, p. 78, 1911.*)

SYDOW, H. & P. . Novæ Fungorum species. (*Annales Mycologici, ix, No. 2, March 1911.*)

THEISSEN, F. . . Fungi aliquot Bombayenses a Rev. Ed. Blatter collecti. (*Annales Mycologici, ix, No. 2, March 1911.*)

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III.—MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,
Imperial Mycologist.

I.—Plant Pathology.

The work of the Mycological Section at Pusa, which was completed during the year, includes investigations on sugarcane diseases, *Rhizoctonia* and *Phytophthora Colocasiæ*.

The chief diseases of sugarcane investigated were red-rot and an undescribed disease caused by a species of *Cephalosporium*, which presents many points of resemblance to red-rot and is frequently confused with it. The actual channels by which the parasites gain entrance to the cane have been determined by a large series of inoculation experiments. It is hoped that the result of the work, an account of which is being prepared for publication, will be to improve the methods by which serious injury from these diseases may be prevented.

Mr. Shaw, Supernumerary Mycologist, has in the press an account of his researches during the past two years into the morphology and parasitism of *Rhizoctonia*, a soil-dwelling parasite with a wide range of victims. Jute, cotton, ground-nut, cowpea, potato and sesame are amongst the plants attacked. Two species are distinguished, *R. Solani* Kühn, of which the perfect fruiting stage is not yet certainly known, and a species with larger sclerotia, of which the fruiting stage is the Basidiomycete, *Corticium vagum* B. & C. For the last, the old name *R. violacea* Tul., ordinarily used to cover both forms, is proposed to be retained. The beginnings of the formation of specialised races on individual hosts can be observed in *R. Solani*, as the race on jute cannot infect cotton, ground-nut or cowpea, while the forms on these last three hosts can pass freely from one to another. No cereal crop has, so far, proved susceptible to the attacks of these parasites and in a proper attention to rotation probably lies the best means of lessening their ravages.

A disease of the country vegetable, *Colocasia antiquorum*, caused by *Phytophthora Colocasiæ* Rac., has been under study by the writer for some time past. The fungus was obtained in pure culture last year and this has permitted of rapid completion of the investigation, the

results of which will be published shortly. The disease resembles in many respects the well-known potato blight caused by *Phytophthora infestans*, especially in persisting from year to year in the tubers and in only forming a true sexual stage in artificial culture. A second species of *Phytophthora*, on castor, is being studied by Mr. J. F. Dastur, First Assistant, and these two researches have added considerably to our knowledge of the genus.

Mr. Burns has published the concluding account of his three years' experiments in the treatment of grape-vine mildew (*Oidium*) in the Bombay Presidency. The results are considered to demonstrate conclusively the usefulness of the treatment. The spray used was Bordeaux mixture of the 6-4-50 formula (6 lbs. copper sulphate, 4 lbs. freshly burnt quicklime and 50 gallons water) to which was added soft soap at the rate of 5 lbs. The latter was intended to make the spray effective against insects and to increase its adhesiveness. Five sprayings are recommended, one about the middle of May, a second about the middle of August, a third about the middle of October, a fourth about the beginning of December and a fifth about the beginning of January. The last two should be at half strength of the mixture. The result of the treatment has been to reduce the number of attacked bunches from 100 to 21 per cent. and of attacked fruits per bunch from 22 to 1 per cent. The cost is estimated as Rs. 22 initial (cost of sprayer, etc.) and about Rs. 40 per acre annual (cost of materials).

Mr. Anstead has published a detailed account of the work done in Southern India in checking "pink" disease of Hevea rubber, caused by *Corticium salmonicolor* B. & Br. He recommends cutting out the affected parts, where the disease has already appeared, and painting the trees with Bordeaux mixture in May or June as a preventive. The formula recommended is 4-4-45 and resin is added to aid the mixture to stick to the trees. The cost is about a pie per tree or not more than Rs. 2 per acre. The results have been very encouraging and experiments are being continued to perfect the methods.

The writer described two diseases of wild vines, one of which is also known to attack the cultivated species. Neither of these diseases occurs in Europe, where, if introduced, they might become serious pests. Both are caused by rust fungi of unusual types.

Mr. Ajrekar has submitted for publication a note on the rust of Castor (*Melampsorella Ricini*). This fungus is known only in the uredo stage. None of the varieties of castor ordinarily grown in Bombay is

immune. The disease is severe in the southern part of the Presidency only.

Mr. G. S. Kulkarni has given a preliminary account of the red-rot of sugarcane in Bombay, in a paper in which the characters of the disease are described, the methods of treatment indicated and a number of interesting field observations recorded. He has also, in conjunction with Mr. Ajrekar, commenced experiments with a view to checking the *Koleroga* of betelnut in North Kanara, where it is responsible for damage estimated at nine lakhs of rupees annually. Further work on the prevention of the same disease, in continuation of that reported last year, was carried out by Dr. Coleman, who issued a vernacular leaflet on the subject.

II.—Systematic Mycology.

Two parts of the descriptive list of Indian fungi, which is being issued by Messrs. H. & P. Sydow in conjunction with the writer, were published during the year. These included the *Ascomycetes* and *Exobasidiaceæ* of the Pusa Herbarium, together with additions to the lists of *Phycomycetes*, rusts and smuts previously published. The total number of additional species recorded was 316, distributed in 108 genera, of which 1 genus and 115 species were new to science. A large proportion of the remainder consisted of species new for the Indian flora. Of the new species the majority (72) were *Ascomycetes*, a group which has received little attention in India, 26 were rusts, 11 smuts, 2 *Phycomycetes* and 4 *Exobasidia*.

The writer described a remarkable aquatic fungus found at Pusa and Poona, assigning to it a position in the family *Leptomitaceæ*. It is an aberrant member of the family, inasmuch as it has a completely segmented thallus. Reasons are given for considering the *Leptomitaceæ* to be a more primitive group than is usually admitted, and for holding them to be derived, through forms resembling *Monoblepharis*, from the *Siphoneæ* amongst the green Algæ.

Mr. Ajrekar has worked out the life-history of *Cystopsora Oleæ* Butl. This rust consists of æcidial and teleuto stages only, the uredo being omitted. The whole life-cycle is passed on the one host, *Olea dioica*.

Mr. Kulkarni has discovered the conidial stage of the *Sclerospora* which is parasitic on jowar and considers that it presents sufficient differences from this stage of *Sclerospora graminicola* to warrant its separation as a distinct species.

List of Publications.

AJREKAR, S. L.	. A note on the Life-history of *Cystopsora Oleæ* Butl. (*Annales Mycologici, x, p. 307, 1912.*)
ANSTEAD, R.	. Bordeaux mixture and Pink disease of Hevea rubber. (*United Planters' Association of Southern India, Bull. No. 1, 1912.*)
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CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

III.—MYCOLOGY.

BY

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Imperial Mycologist.

I.—Plant Pathology.

Agricultural Research Institute, Pusa.—The following is an account of the chief diseases of plants investigated at Pusa during the year.

Rice diseases.—A disease of inundated rice, of a very serious nature, has broken out in the deltaic districts of Eastern Bengal, where it is locally known as *ufra*. Much time was given to its investigation. It has been found to be caused by a minute parasitic nematode worm, of the genus *Tylenchus*. Though not mycological, it is referred to here, as, in the absence of any agricultural Helminthologist in India, its further investigation has been taken up by the writer. The parasite, a hitherto undescribed species, attacks especially the deep-water winter rice so extensively grown in the area referred to, and the intensity of the attack is such that affected fields are frequently not considered worth harvesting. In the backward state of agricultural information in Eastern Bengal, it is difficult to arrive at even an approximate estimate of the losses, but they are undoubtedly very heavy and there is evidence that the disease is spreading. The parasite is allied to two of the worst worm parasites of crops known, *Tylenchus tritici* and *T. dipsaci*. It appears to be strictly parasitic on rice, being unable to grow and multiply in the absence of living rice plants. It feeds by piercing the epidermis of those parts of the plant where the outer wall is unthickened and not silicified and, consequently, is restricted to certain definite parts of the plant: the apex of the shoot, the young leaves, above the upper stem nodes, and the young ear being the chief. The result of its attacks is to prevent the ear from maturing properly and there is total or partial loss of the grain. It passes the period between successive crops coiled up, in a resting condition, in the stubble and can stand drying in this condition for over a year. No evidence has, as yet, been obtained that it hibernates in the soil; if subsequent work confirms this, there is a good

prospect of being able to fight it by destroying all stubble left after harvest, and experiments in this direction are being carried out.

The chief fungus diseases of rice studied were bunt, caused by *Tilletia horrida* Tak., false smut caused by *Ustilaginoidea virens* (Cke.) Tak. and a disease caused by *Sclerotium Oryzæ* Catt. Accounts of these diseases have been published since the close of the year under review.

Root rot of various crops.—A description of the morphology and parasitism of two species of the form genus *Rhizoctonia*, soil parasites which attack the underground parts of several crops, was published. Cotton, jute, groundnut, cowpea, potatoes and sesamum are amongst its victims. More recently, it has been found to cause opium blight and to damage lucerne. The published investigations deal with two species, *R. Solani* Kühn on jute, cotton, potato, groundnut and cowpea and *R. violacea* Tul. on groundnut and cowpea. The latter is shown to be an imperfect stage of the basidiomycete *Corticium vagum* B. & C. Details of their morphological characters in culture and their behaviour as parasites, are given.

Phytophthora investigations.—Two species of this most destructive genus of fungus parasites, *Ph. parasitica* Dastur and *Ph. Colocasiæ* Rac., have been under study, and the results were published. *Ph. parasitica* causes a disease of young castor plants, being the most serious disease of the crop known. It was obtained in pure culture and this permitted of a very full study of its characters and parasitism. The chief interest centres in the discovery of a new type of reproduction, a discovery which was anticipated by a British Mycologist, working with an allied species, shortly before the publication of the paper. A very complete series of inoculation experiments was carried out, potato, tomato, brinjal, til and several other plants proving susceptible to attack.

Ph. Colocasiæ attacks the country vegetable, *Colocasia antiquorum*, and, under certain conditions, causes much damage both to the growing crop and, subsequently, to the stored corms. The intensity of the attack is closely dependent on the character of the monsoon, being worst in wet years. The parasite was cultivated artificially and a large series of inoculation experiments carried out, which showed that it has a very restricted range of victims. It possesses the same remarkable type of reproduction as *Ph. parasitica*.

More recently *Ph. infestans*, the cause of the well-known potato blight, has been under study, a serious outbreak having occurred in Bihar and Bengal last year. It has also been obtained in pure culture and it is hoped to get some light on the reason why it is so rarely found in the hotter parts of India.

Sugarcane diseases.—The progress in the investigation of several diseases of this crop is referred to in the Pusa Annual Report for 1911-12.

The work has extended over a number of years, owing to difficulties encountered in carrying on field experiments. It has been so far completed as to allow of the preparation of two Memoirs now in the press, one on red rot (caused by *Colletotrichum falcatum* Went), and a second on some new sugarcane diseases. The chief points elucidated are the channels of natural infection of the crop, in some of the more important stem diseases, and the methods of control to be adopted in practice. These will be referred to more fully in the next report.

Wheat rust.—A severe attack of wheat rust, the first for a number of years, occurred in the Central Provinces in 1912. It was found that orange rust (*Puccinia triticina*) was responsible for much of the damage, though in ordinary years scarce in that part of India. Black rust (*P. graminis*) was also severe. Hence, in breeding rust-resistant wheats, the behaviour to these two rusts must be chiefly considered and, as orange rust may be absent in ordinary years, it may be necessary to carry out some of the work in parts of India where orange rust occurs annually.

Anthracnose of sisal hemp.—This was definitely proved to be due to the fungus *Colletotrichum Agaves* Cav. previously suspected to be its cause. It infects various species of *Agave* readily, and produces a characteristic leaf disease. Collecting and burning diseased leaves, and spraying with Bordeaux mixture, are recommended as measures likely to check the disease.

Damping off.—This seedling disease, caused by *Pythium de Baryanum* Hesse, was not previously reported from Asia, but has been found to occur occasionally at Pusa. It was studied, and some doubtful points in its morphology cleared up. In temperate countries it causes a good deal of loss, but does not appear to be a serious danger in India.

Cereal downy Mildews.—These diseases, caused by members of the genus *Sclerospora*, appear to be of greater importance in India than elsewhere. Maize, several of the more important millets and a fodder grass, are amongst the crops affected. The maize mildew appeared at Pusa for the first time last year, and is probably a recent importation from Java, where it has been known since 1897. It has not yet been found in any other country, but in Java causes much loss. From its investigation at Pusa, it was found to be closely allied to the form on jowar (*Andropogon Sorghum*) and to be a true *Sclerospora*, not a *Peronospora* as stated by investigators in Java. It was also shown that the resting-spore stage described in Java, by which the disease was supposed to be perpetuated, had in reality nothing to do with the fungus, being merely the cystic stage of a Protozoon. Nothing is known of the life-history of the *Sclerosporas*, and observations are being continued in the hope of determining how the parasite persists from one season to the next. Until this is decided, it is not possible to find a rational method of con-

trol, and the only measure that can be recommended is to pull out and destroy all diseased plants, which can only be done in mild attacks.

Mr. Kulkarni, Mycological Assistant, Bombay Department of Agriculture, has given reasons for separating the *Sclerospora* on jowar from that on bajri (*Pennisetum typhoideum*) as a distinct variety, to which he has given the name *Sc. graminicola* var. *Andropogonis Sorghi*. He has also furnished useful notes on the field characters of these mildews.

Indigo blight.—This obscure disease has been under study for some time, but no parasitic organism has been found constantly associated with it and it is considered to be non-fungal in origin. A considerable number of different organisms, mostly of the class known as weak parasites, were isolated from individual plants, in various stages of the disease, but none proved capable of reproducing it. The mycological side of the enquiry has, therefore, been abandoned.

Miscellaneous.—Notes are given in the Annual Report of the Mycological Section, Pusa, for 1911-12, on a number of other diseases of plants studied during that period. The more important were cotton wilt, anthracnose of plantains, foot rot of papaya, lucerne and cauliflower mildews and a number of forest tree diseases. The successful treatment of oat smut by formalin steeping is recorded, and notes are given on the areca palm disease in North-Eastern India, believed to be caused by *Fomes lucidus* (Leys.) Fr.

Provincial Departments of Agriculture.—The following are the chief items of mycological work carried out by Provincial Departments of Agriculture and referred to in the reports published during the year.

Madras.—Mr. McRae continued the campaign against bud-rot of palms (caused by *Pythium palmivorum* Bult.) in the Godavari and Kistna Districts. Some extensions of the disease outside the area covered by the operations were discovered and dealt with. In Kistna there is a distinct decrease in the area affected, as a result of the work, but the checking of extension in the upland forest area is a serious problem. In Godavari the area remains practically the same and there is no decrease in the number of trees cut periodically. In a paper published in the *Agricultural Journal of India*, Mr. McRae calls attention to the danger of allowing palms, which have spots caused by the parasite on the expanded leaves, to remain uncut. The fungus in this position is exposed to wind dissemination and each such tree serves as a centre of spread to surrounding palms. Fortunately the number of cases in which the parasite attacks the leaf blades is small. As there is a difficulty in inducing the ryots to allow these to be cut, a proposal has been made to employ some form of compulsion.

Mr. McRae carried out extensive experiments in spraying areca palms, affected with the *Koleroga* or *Mahali* disease (caused by *Phytophthora omnivora* var. *Arecæ* Coleman), in South Malabar, with such success that the owners have asked that the work should be continued. The increased profit per 100 trees sprayed was over Rs. 20.

A bud-rot of coconuts was reported from Malabar. It was at first believed to be identical with that of Cuba and the West Indies, the cause of which is *Bacillus coli*, but recent reports indicate that it is due to *Pythium palmivorum*. It is, at present, impossible to gauge the importance of this outbreak, but the chief fear which has always been felt by those responsible for the work against this parasite in Madras, has been that it should develop with virulence in the enormously valuable coconut plantations of the West Coast.

Other work in Madras included unsuccessful attempts to secure inoculations with the false smut of paddy [*Ustilaginoidea virens* (Cke.) Tak.], stringent selection of the sugarcane crop at Samalkota with a view to checking red rot, and the study of several diseases of various crops.

Mysore.—Dr. Coleman continued work in connection with the *Koleroga* disease of areca palms, and the parasitism of *Fomes lucidus* on the same tree.

Bombay.—Mr. Ajrekar published a note on the rust of castor (*Melampsorella Ricini* de Toni). Work in connection with the control of *Koleroga* of areca palms and red rot of sugarcane was continued.

Central Provinces.—Work was confined to observations on the behaviour of varieties of wheat to rust, with a view to securing rust-resisting strains, and further tests of the immunity of buri cotton to wilt. The latter were eminently satisfactory, almost complete immunity being shown, even when planted in fields very severely infested with wilt. As the variety yields the cultivator about Rs. 40 less per acre than the cottons ordinarily grown, its use is likely to be restricted to wilt-infested areas.

Bihar.—Mr. Basu studied the outbreak of *Phytophthora infestans* on potato and has published a note on it since the close of the year under review.

Burma.—The anthracnose of cotton (caused by *Colletotrichum Gossypii* Southw.) was found on Pernambuco tree-cotton. A short note giving suggestions for its control was published as a departmental leaflet.

Indian Tea Association.—Mr. Tunstall has contributed a number of notes on tea diseases to the Association's Quarterly Journal. These deal chiefly with root diseases, the commonest being those caused by *Ustulina zonata* Lev., *Hymenochæte noxia* Berk. and *Botryodiplodia*

Theobromæ Pat. Besides the measures previously recommended for the check of these diseases, experiments were carried out with a new treatment, consisting in the application to the soil of ammonium sulphate and lime in equal parts, after removing all dead roots. This results in the liberation of ammonia, which is stated to inhibit the growth of the parasite.

Of leaf diseases the chief referred to are blister blight, caused by *Exobasidium vexans* Mass., and copper blight, caused by *Lœstadia Theæ* Rac. Blister blight was observed in Darjeeling and North-East Assam. It has been found to persist through the cold weather on old nurseries, seed gardens and abandoned tea, and it is recommended that attention should be directed to preventing infection from these sources. None of the plucking area should be left unpruned and no abandoned tea or old nurseries should be kept; all seed gardens should be sprayed with Bordeaux mixture; and planters should unite so as to secure concerted action in stamping out the disease. Copper blight is said to be on the increase, but to cause comparatively little damage at present.

II.—Systematic Mycology.

There is little to record under this head during the year. A few new species have been described from India by Saccardo and Sydow. Dietel points out that the common Himalayan rust of wild vines cannot be identified with *Phakopsora Vitis* Syd., but is a distinct species, which he has named *Phakopsora cronartiiformis* (Barcl.) Diet. Theissen has commenced the publication of a compilation, giving a list of the Fungi of India, in the Journal of the Bombay Natural History Society.

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Dietel, P. . .	Eine Bemerkung über *Uredo cronartiiformis* Barcl. (*Ann. Mycol., x, p. 385, 1912.*)
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,, ,, .	. Anthracnose of Sisal hemp. (*Agric. Journ., India, viii, p. 65, 1913.*)
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CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

BOTANY.

III.—MYCOLOGY.

BY

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Imperial Mycologist.

PLANT PATHOLOGY.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations at Pusa during the year.

Rice.—The most important disease at present under investigation is that known locally as "ufra," which continues to extend and is causing widespread alarm in Eastern Bengal. Practically the whole of the districts of Noakhali, Tippera and Dacca is now infected and extension is going on into Mymensingh and probably Sylhet. The loss caused in those areas—and they are many—where the main crop is deep-water paddy and little else will grow, is very great. Estimates are difficult to obtain, but it has been calculated that in a small portion of the Bhowal Pargana of Dacca District over 2¼ lakhs of rupees, worth of paddy is annually destroyed, and there have been many reports of the misery to which the people of some of the villages have been reduced. Conclusive evidence has been obtained that the cause of the disease is the microscopic eelworm *Tylenchus angustus* Butl., described in 1913. The parasite hibernates in the dried stubble which covers the fields after the harvest of the main crop in November-December, and renews activity with the coming of the floods and high humidity of the rains. It is a semi-aquatic species, surviving for some weeks in water but unable to grow or moult under such conditions. It is actively motile in water and can travel both with and against the stream to reach its host plant. On a dry surface it is unable to move, unless the humidity of the surrounding air is high, but tends to coil up and pass into a dormant condition. Hence extension is limited to the period of high humidity and flooding, and the first patches of disease are not usually seen before July. On reaching the host plant, the worm ascends, if the humidity be sufficient to permit movement, moving in a minute drop of condensed moisture around the body. It makes its way as rapidly as possible to such parts of the plant as have unthickened epidermal walls, penetrating especially into the folded leaf-bud to reach the youngest leaves in the centre of the shoot, but liking also the flexible stem region just above the upper nodes, and the young ear and florets. Feeding and consequent injury

to the plant is limited to these regions, as the feeding apparatus is unable to penetrate the more solid parts. At no period is the worm found actually to enter the tissues ; it lies on the surface and sucks out the juices through perforations made by a fine spine. Artificial inoculations on small seedlings may give visible results in a week, while on full-grown plants the first symptoms may take a month to appear. If the number of worms is large, death may occur within a couple of months, but in very many cases the plant is only weakened, not killed. Complete or partial sterility, failure of the ear to emerge from the sheath and failure of the grains to mature, are common consequences of the attack. It was found possible this year to carry the worm in an actively parasitic condition through its normal period of dormancy (say from December to April) by supplying it with continually renewed young paddy seedlings, kept surrounded by moist air. In dry air, however, the inoculations failed. So far the experiments at Pusa indicate that if the above-ground parts of the plant are dry, extension does not occur, and this explains the comparative immunity of the early ("aus") crop, and of the main (" aman") crop in its earlier stages. It is probable also that the spring ("boro") crop is not liable to injury, but this point has not yet been settled and the crop is, in any case, of relatively minor importance.

Experiments show that a diseased plot will inevitable give a diseased crop the following season if the stubble is allowed to rot on the ground as is the usual practice in the infected area, but if all the stubble is destroyed a healthy crop can be grown. Several experiments have been carried out to test the ability of the worm to remain alive in the soil, but it does not seem able to survive in this way between successive crops. Hence the treatment resolves itself into dealing with the stubble, and work is in progress in collaboration with the Bengal Department of Agriculture to test the best way of removing or destroying this. Thorough burning has been proved to be effective on small plots ; ploughing in the debris of the crop as soon as possible after harvest may prove equally satisfactory ; or a combination of the two may be found most convenient. The transplanted " aman " fields are rarely damaged, owing probably to the practice of harvesting this crop with most of the straw, but there is scarcely any other part of India where the stubble is left to rot in such quantity as on the lower class of land in the eastern districts of Bengal. The Bengal Department is carrying out extensive experiments and has commenced demonstrations in destroying stubble ; early ripening varieties, which suffer less than the later kinds, are being tested ; and an detailed survey of the infected tracts is also in hand.

Orobanche on tobacco and mustard.—The work of the past two seasons has established that the parasitic species of *Orobanche* in Bihar are *O. indica* Ham. and *O. cernua* Loefll. The species *O. cernua* is the common parasite of solanaceous crops in Bihar, but does not appear to attack *Cruciferæ* save in very exceptional circumstances. In a crop of mustard, grown in a field known to be badly infected with both species of *Orobanche*, only four cases of *O. cernua* were found among many thousands of *O. indica*. The parasitism of

O. cernua therefore is more restricted than is that of *O. indica* which, while being a serious parasite of *Cruciferæ*, does occur to a not inconsiderable extent on *Solanaceæ*. The life histories of the two species seem to be identical, the " tokras " appearing a few weeks after the host crop is well established and rising to flower and fruit along with it. Both species rely on the production of countless millions of minute seeds for their dissemination and perennation. These seeds are present all over the cultivated lands of Bihar, their number and minute size being extremely favourable to their dispersal in the strong winds of February and March when the fruits of *Orobanche* are ripe.

Experiments were carried out during the year with a view to discovering whether the addition of quantities of sodium nitrate to crops of mustard and tobacco had any influence on the number of tokras which occurred in the crops. Plots of equal size were selected in land which was known to be infected with both species of *Orobanche*, and the numbers of tokras occurring in plots to which sodium nitrate had been added were compared with the numbers of tokras in plots which had not received any nitrate. A difficulty which renders the results of the first season's work on these lines somewhat inconclusive is that the number of tokras appearing in a plot will depend, apart from any influence of artificial manures, on the amount of tokra seed which the plot contained. This factor appeared in many cases to mask any effect which might have been due to the addition of sodium nitrate. The work will be continued for another year in order to eliminate this source of error but the results obtained to date do not lend any support to the view that sodium nitrate will be found a specific remedy for tokras.

Black thread of rubber.—Work on the " black thread " disease of *Hevea* in Burma was continued. A popular account was published as a bulletin of the Burma Department of Agriculture and a more technical memoir is in the press. The disease first breaks out soon after the rains begin and completely disappears after the close of the monsoon. It is not fatal to the tree but does much damage by attacking the tapped area of the bark. Infected areas do not yield latex and severely diseased trees have to be excluded from the tapping round. In 1914 the loss of rubber on one estate was 2-3,000 lbs. and in 1915, 8-9,000lbs., there being 12,000 trees affected in 1914 and 42,000 in 1915, out of 77,000 in tapping. The cut surface of the tapped bark becomes marked by vertical cracks, from which latex occasionally exudes ; sometimes a thick cushion of coagulated latex forms below the renewing bark, causing the latter to bulge out and ultimately fall off, so as to leave an open wound. The renewal of the bark is irregular, masses of callus appear on the cut surface and further tapping is hindered.

The cause of this damage is a species of *Phytophthora*, differing from the well-known canker fungus, *Phytophthora Faberi*, to which it had been attributed in the Dutch Indies. It seems to occur in Ceylon also but has been there supposed to result from climatic conditions. In South India the same fungus is believed to be responsible for considerable damage and is at present under study by the Madras Department.

The fungus is found both in the diseased bark and also on the fruits. It has been grown in pure culture and an extensive series of inoculations carried out both on rubber and on numerous other plants known to be attacked by species of *Phytophthora*. On rubber it is a wound parasite, being unable to infect the undamaged bark ; through wounds it infects readily and produces the characteristic symptoms of the disease. Of the other plants tried, the ordinary hosts of *Phytophthora infestans*, *Ph. parasitica* and *Ph. Colocasiæ*, the three species most commonly found in Northern India, are immune, as also is cacao, one of the chief hosts of *Ph. Faberi*, and many other plants known to be liable to *Phytophthora* attack. Only on seedlings of the garden plants, *Gilia* and *Salpiglossus*, were successful infections secured.

The disease is favoured by excessive humidity and shade and is, therefore, worst in thickly planted rubber estates. The free admission of sunlight and air checks its progress, and good results may be obtained from judicious prunning and thinning. The chief source of infection seems to be the fruits, and as these have practically no value and develop in the rains a copious growth of the parasite, from which spores are shed on the bark, it is recommended that all fruits be carefully picked and destroyed before the monsoon breaks, in infected plantations.

In continuation of the studies on allied species of this genus which have been carried on at Pusa in recent years, an account of a form of *Phytophthora parasitica* found on *Vinca rosea* has been recently submitted for publication. Germination of the durable type of spore (the oospore) has been obtained and was found to correspond in essentials with that described for *Ph. erythroseptica* in Ireland.

Opium poppy blight.—The investigation of this disease has led to the conclusion that while *Peronospora arborescens* is a normal parasite present in almost every poppy field and probably, like most of its tribe, only epidemic under favourable climatic conditions for its spread, *Rhizoctonia* develops chiefly in fields in which the drainage is defective. The Economic Botanist, United Provinces, has discovered certain varieties which appear to be almost immune to *Peronospora* and in the growth of these and improved cultivation and drainage lies the best hope of preventing loss of the crop.

Rhizoctonia.—A joint paper on this genus was published by Mr. Shaw, Officiating Imperial Mycologist, and Mr. Ajrekar, Assistant Professor of Mycology, Agricultural College, Poona. The species dealt with are *R. Napi* West, an omnivorous parasite first observed in India in 1914, and *R. destruens* Tassi, which attacks potato, betle vine, lucerne, groundnut and suran (*Amorphophallus*). Evidence was obtained that the genus as at present defined is an artificial one, including representatives of at least two distinct classes of fungi ; occurring as they do usually in the vegetative condition only, identification is difficult, and the difficulty is increased by their omnivorous tendencies, groundnut, for instance, being liable to attack by at least three species. The

biology of the forms, especially *R. destruens*, was studied and suggestions for treatment are given.

Samples of jute seed from Dacca were found to contain the sclerotia of *Rhizoctonia Solani* Kühn adhering to the seed. The parasitism of this fungus upon jute has been the subject of a previous publication, but up to the present *R. Solani* has been a source of damage in the region of the " collar " and has not been known to infect seed. It is not clear how this comes about and the matter will receive further investigation.

Specimens of sugarcane received from the Central Provinces were found to be infected with a sclerotial fungus. The fungus was obtained in pure culture and strongly resembled *Rhizoctonia destruens* Tassi. ; moreover inoculations upon *Delphinium* (the original host of *R. destruens*) and upon betle vine were successful. Further infections upon sugarcane resulted in the death of the outer leaves and of the young shoots at the base of the plant ; the infections are still progressing at the moment of writing. In the field the fungus causes a bright red spot on the leaf sheath and this is the first noticeable result in artificial infections. In badly diseased specimens the leaf bases are a dark red and have a fibrous appearance as if the parenchyma had been rotted away leaving the vascular bundles. On stripping the leaf bases the stem has a pale pink colour under the epidermis, and in section the interior shows a generally diffused salmon pink colour, partly obscured by a thick white felt of hyphæ. The mycelium shows a tendency to form strands of hyphæ in a manner suggestive of *R. destruens*. Further research is in progress.

Anthracnose of peppers.—The disease of betle pepper referred to in previous reports as being probably due to an anthracnose fungus, has proved more difficult to elucidate than was anticipated. All attempts to produce it artificially by inoculating with cultures of the suspected fungi have failed. In the absence of definite knowledge of the cause no useful recommendations for treatment can be offered.

The chilli anthracnose (due to *Colletotrichum nigrum*) is a serious disease of this crop in several parts of India. It was prevalent in Bihar last year and some spraying experiments were tried. Later on it appeared that a more hopeful line of treatment lay in the use of disease-free seed and investigations are in progress to test this method. It has been found that, as in the allied bean anthracnose, the parasite penetrates the pod and reaches the seed. If such seed be sown the following season a certain number germinate and give seedlings on which the fungus may be found. Such seedlings must serve as a source of infection to their neighbours and it seems probable that this is one of the main ways by which the disease is perpetuated. If seed only from healthy pods be used this source of infection can be eliminated and further experiments are in progress to test the effect of this on the subsequent crop.

Plaintain diseases.—An account of a plantain disease prevalent at Pusa was published early in the year. It is a wilt, caused by a species of *Fusarium* allied to, but distinct from, that which causes the dreaded " Panama " disease

of the New World. The parasite was grown in pure culture and successful inoculations with it secured. In mild attacks the growth of the plant is not checked but in more severe cases the rot reaches the stem and may kill the whole crown. Much loss is also caused when the stalk of the fruit bunch becomes attacked as this may lead to total destruction of the bunch. No method of treatment has been found.

A second plantain disease, familiar in India, is the fruit rot caused by *Gloeosporium musarum*. Attempts to check this by spraying have been in progress for a considerable time. It has been found that early spraying with Burgundy mixture, beginning in June and repeated every fortnight until the fruit is nearly ripe, when ammoniacal copper carbonate should be used, is successful in preserving the fruit from the disease. An account of the method has been published.

Sal tree disease.—The disease of sal trees, mentioned for the first time in the last annual report has appeared again this year in the forest of Buxa Duars and is also reported in the Gorakhpur division. The symptoms of the disease and the fungus which occurs on diseased trees are exactly the same as in the previous description. Specimens of the fungus sent to Kew have been identified as *Polyporus Shoreæ* Wakefield —a species new to science— and the description published in the Kew Bulletin. The fungus is said to be readily distinguished from other species by the hard but brittle texture of the pileus, especially of the pores when dry, and the wrinkled deeply cracked dark crust. In living specimens the soft swollen whitish margin of the pileus is a distinctive feature. The basidia are normal and each bears fine hyaline spores from 2·5 to 3·5 μ in diameter.

In culture the fungus grows well on a variety of media. On glucose agar the mycelium is largely submerged and produces a dense brown pigment ; the hyphæ very often segment into spores. On sterile corn meal the fungus nearly always produces structures which suggest fructifications ; so far however they have not produced any basidia or spores. The excretion of a yellowish liquid is a feature common to these structures in culture and to the pileus in the field.

Inoculations were carried out in the jungle at Rajabhatkhawa in September of last year but defects in the method of this preliminary experiment, combined with the lateness of the season at the time of making the infection, proved unfavourable and no conclusive results have so far been obtained. The inoculations were repeated this June with modifications suggested by the previous experiment and a further series of infections is about to be carried out at Dehra Dun in co-operation with the Forest Botanist ; it is hoped that these will yield decisive results.

Wilt diseases.—Wilts of cotton, til, gram, chillies and other crops have continued to engage attention. Nothing has been found to support the suggestion made by other investigators that this class of disease is due to defective physical conditions in the soil, especially to interference with the

supply of air to the roots. On the contrary our experience is in harmony with that in other countries such as Germany and the United States, that the principal factor involved is the presence of the parasite (*Fusarium*). As stated by Orton in the United States, " the plants are attacked when otherwise healthy and growing in soil, which, previous to its infection by this fungus, was ideal for their best development. The disease occurs in fields that are neither too dry nor too wet." " If anything, wilt is worse on highly cultivated and well fertilized fields." " Wilt occurs principally in sand, sandy loam, and light alluvial soils."

Miscellaneous.—The question of legislation for the prevention of the spread of plant diseases is one that is attracting much attention at the present time, and in 1914 a draft International Convention for the purpose secured wide support, being signed by the delegates of some 30 States. The writer has carried out a detailed examination of the facts on which international legislation of the kind should be based and especially of the means of dissemination of parasitic fungi, and has recently submitted some papers on the subject for publication.

OTHER SCIENTIFIC DEPARTMENTS.

The following are the chief items of mycological work carried out by other scientific departments, chiefly the Provincial Departments of Agriculture.

Madras.—The Government of Madras have issued a report on the operations for eradicating palm bud-rot in Godavari, Kistna and Malabar during the half-year ending 30th June, 1915. The method at present in force is a detailed examination of every palmyra palm in every known centre of disease, so as to detect the early stages of the attack. The diseased areas of the crown are cut out and burnt, in many cases without subsequent injury to the tree. In Kistna the total number of trees examined was 161,500, of which 0·26 per cent. were found to be dead, 0·5 per cent. had external signs of infection, and 6·2 per cent. had only internal signs visible on stripping off the outer leaves. The effect of this treatment is already visible, the total number of new infections being apparently halved as a result of the first year's work. In one holding, out of 375 trees, 247 were found to be infected and the owner had abandoned working it, because of the virulence of the disease. After treatment all recovered and when again examined the following season only 20 new cases were found. These were dealt with and it is hoped to renew working the trees shortly. In Godavari 57,835 trees were examined in certain tracts, of which 8·6 per cent. were diseased. In addition the work of cutting out dead trees was continued in the rest of the area, about 22,000 being cut. This is the lowest figure in any half-year since 1911, and is a hopeful sign that the campaign is at last beginning to tell on the disease within the infected area. It has been very fairly successful in preventing extension outside this area, but has not hitherto had any marked effect in reducing the virulence of the epidemic. In Malabar, where the coconut is chiefly attacked

and the disease is sporadic, cases have been found in 102 villages in the last two years and the total number of trees cut and burnt in the half-year was 4,428, out of 4,503 reported infected. As the number of cases is relatively small, the coconut being much more resistant than the palmyra, it is proposed to suspend the campaign in Malabar and rely on propaganda to get the people themselves to deal with the disease.

The Madras Mycologist is engaged on the study of a disease of Hevea rubber which, as already noted, seems to be identical with the " black-thread " disease of Burma. The cause has been determined to be a species of *Phytophthora*, of which the biology and life-history have been worked out. The results of the investigation will, it is hoped, be published shortly, together with a description of the parasite, which is believed to be new to science. Amongst other diseases studied by the same officer are one of paddy caused by *Ephelis Oryzæ* Syd. ; a root disease of coffee associated with *Fomes australis* Fr. ; a chilli disease caused by *Vermicularia Capsici* Syd., which can be prevented by spraying with weak Bordeaux Mixture ; and a leaf disease of turmeric caused by *Vermicularia Curcumæ* Syd.

The Deputy Director for Planting Districts has been carrying out experiments in collaboration with the Director of Agriculture, Mysore, and the Madras Mycologist, in the treatment of the diseases of certain plantation crops. With Dr. Coleman a large measure of success has been achieved in checking black rot (" koleroga") and leaf disease of coffee by spraying with Bordeaux Mixture. The results so far obtained point to the probability of the efficacious control of these diseases, the cost, approximately Rs. 15 per acre, being by no means prohibitory, in view of the heavy monetary loss annually incurred from them. With Mr. McRae observations on the secondary leaf-fall of Hevea (believed to be due to the same parasite as that causing " black thread ") have been made, and field experiments have been carried out to ascertain the cost of removing dead branches from attacked trees. The " brown blight " of tea has also been jointly studied and spraying with Bordeaux Mixture has proved successful in restoring attacked nursery plants to vigour. The parasite (*Colletotrichum Camelliæ* Mass.) has been grown in pure culture and the effect of fungicides on it tested. The recommendations for its treatment are as yet tentative, but further experience should allow of a satisfactory control of this troublesome disease. Notes on these and other diseases of tea, coffee, rubber and the like have been published in the " Planters' Chronicle."

Mysore.—Dr. Coleman's work on spraying coffee, in collaboration with Mr. Anstead, has been referred to in the last paragraph. He has also completed his investigation on " koleroga " of coffee sufficiently to allow of publication. The full paper has not yet appeared, but from a note in the Planters' Chronicle it is evident that Dr. Coleman has independently discovered the true nature of this parasite, announced some years ago by von Höhnel in Vienna from the examination of herbarium material. Von Höhnel's study was necessarily restricted from want of material and Coleman's full paper

will be awaited with interest and should throw light on a very obscure class of parasites. Other diseases of coffee are also being investigated. The measures to control the "koleroga" of the Areca palm have been described in a paper in the "Agricultural Journal of India" in April, 1915. Further work has given evidence to indicate that the disease (due to *Phytophthora Arecæ* (Colem.) Pethy.) can be definitely stamped out from isolated areas. One garden situated in an unfavourable area has had no disease for the past four years, though before treatment was adopted, it was always badly affected. During the past year it has remained untreated without getting the disease. Measures to enforce treatment are being considered which, if adopted, will enable the Department to extend these operations to a very great degree in the future. Dr. Coleman has also taken up the study of the obscure disease of the sandal-wood tree known as "spike disease," apparently an enzymatic affection. It has been definitely proved that the disease is communicable and a preliminary report will be published shortly. Other work includes studies on a *Fusarium* disease of potatoes and on mango mildew.

Bombay.—Mr. Ajrekar's work on *Rhizoctonia*, in collaboration with Mr. Shaw of Pusa, has already been referred to. He has also carried out an investigation of sugarcane smut, examining particularly the mode of infection and the effect of treatment by steeping the setts in copper sulphate solutions. The latter was found to be useless in preventing smut and injurious to the cane. A note on the work has been submitted for publication. A disease of fruit trees caused by a species of *Nectria* is under study and observations have also been made on several other diseases of cultivated plants and on the life history of a jasmine rust.

Mr. Kulkarni, Assistant Mycologist, has completed a detailed study of the smuts of jowar in Bombay, part of the work being done at Pusa. The results are not yet published, but the presence of four distinct smuts in this crop, two of which can be readily prevented, has been demonstrated. The Department is carrying out an extensive campaign against these diseases, with considerable success. Arrangements have been made with a local agency for the sale of 1 anna packets of copper sulphate, each sufficient to treat the seed for 4 acres and containing full directions for use. Some 40,000 of these packets were sold and it is calculated that, if all were properly used, a saving of about 3 lakhs of rupees to the cultivators must have resulted. As the annual loss probably exceeds a million sterling in the Presidency, and as the treatment is simple and likely to appeal to the people, the Bombay Department seems to have a very fair chance of repaying to the country in a single year more than the whole cost of the Department up to date.

In other directions the Department is also showing activities of a distinctly practical kind. The spraying of Areca palms against "koleroga," based on the work started in Mysore some years previously, is rapidly extending in the southern districts, over 9,000 having been treated, against less than 2,000 the previous year. The owners are now taking up spraying for themselves, with excellent results. Spraying grape-vine mildew has also been

taken up by the vine growers at Nasik, a recently introduced modification, which keeps the fruit free from stains, having increased the popularity of the treatment.

Central Provinces.—In this area also the smuts of jowar cause great annual loss and the copper sulphate treatment has been demonstrated with success for several years. One of the smuts appears to be less readily prevented than the commoner forms and experiments with this variety have been commenced. The loose smut of wheat is prevalent in the north of the Provinces and is difficult to check by any of the usual steeping methods. An important feature of the year's work has been the isolation of a rust-resisting cross-bred wheat.

United Provinces.—The Economic Botanist has been investigating the poppy blight prevalent in opium-producing districts and has come to the following conclusion. Of the two affections which combine to damage the crop, the root rot (due to *Rhizoctonia*) is largely dependent on cultivation conditions and where these are good the disease will not be serious. The disease caused by *Peronospora* falls in a different category and its incidence depends on the climatic conditions. The different races of poppy show great divergence in power of resistance to the disease and the best results in minimising the ravages will be found in the selection of pure races of poppy which is now in progress.

Bengal.—The work of this Department in connection with ufra disease of rice has already been referred to. Some demonstrations on spraying for potato disease were made at Rangpur and Narayanganj.

Indian Tea Association.—Mr. Tunstall, the Mycologist of this Department, has continued his investigation of the fungi which attack the roots of tea and has published the first part of a pamphlet on tea roots. A key to the identification of the root parasites, with plates, has been included. A second part of this pamphlet is in preparation. The fungi causing leaf diseases have also received attention. Grey blight has been found to be due, not to *Pestalozzia palmarum*, as often stated, but to an allied species. The brown blight fungus, *Colletotrichum Camelliæ* Mass., has been shown to be distinct from the *Glœosporium* which attacks tea leaves and stems, causing die-back. Rim-blight is still obscure, but a species of *Alternaria* is suspected to be the cause. Much time has been given to the practical questions of checking these blights and especially to spraying. The types of machines most suitable are being enquired into. Knapsack sprayers worked on the battery system by compressed air have given the best results, but a more automatic method would be an improvement and is being sought for. The Mycologist has published several notes in the Quarterly Journal of the Association.

SYSTEMATIC MYCOLOGY.

The fifth part of the series " Fungi Indiæ Orientalis " by the writer, in conjunction with Messrs. H. and P. Sydow of Berlin, has been published. It

is based on material sent to Germany before the war and was probably almost ready for press before communications were severed. It contains the first part of the collections of *Deuteromycetes* in the Pusa Herbarium, comprising the *Sphæroideæ* (173 species), *Nectrioideæ* (7 species), *Excipulaceæ* (4 species), *Leptostromataceæ* (3 species) and *Melanconiaceæ* (8 species). Seven new genera and 97 new species are described, the large proportion (nearly 50 per cent.) of new forms being an indication of the little attention previously given to this group in the East. Many of them are crop parasites but they are not, on the whole, responsible for as much damage as the mildews, rusts and smuts. A few other miscellaneous Indian fungi from previous collections have been named during the year. The writer also took an opportunity while on leave, of checking the nomenclature and establishing the identity of several Indian parasitic fungi, by comparison with the collections at Kew.

List of Publications.

ANDREWS, E. A. & TUNSTALL, A. C. — Notes on the spraying of Tea. (*Indian Tea Assoc., Pamphlet, No. 1, 1915.*)

ANONYMOUS . . . — Fungi Exotici, XX. (*Kew Bull. 1916, No. 3, p. 71.*)

Annual Reports of the Agricultural Research Institute, Pusa, and of Provincial Departments of Agriculture.

DASTUR, J. F. . . — A Rot of Bananas. (*Agric. Journ., India, x, 278, 1915.*)

,, . — Spraying for Ripe-rot of the Plantain Fruit. (*Agric. Journ., India, xi, 142, 1916.*)

,, . — Black-thread disease of Hevea in Burma. (*Burma Dept. Agric., Bull. No. 14 of 1916.*)

MACRAE, W. & ANSTEAD, R. D. — Brown Blight of Tea (*Colletotrichum Camelliæ*). (*Planters' Chron., xi, 2, 1916.*)

MCRAE, W. & SUNDARARAMAN, S. — Leaf-fall in Hevea. (*Planters' Chron., x, 452, 1915.*)

SHAW, F. J. F. & AJREKAR, S. L. — The genus *Rhizoctonia* in India. (*Mem. Dept. of Agric., India, Bot. Ser. vii, No. 4, 1915.*)

SYDOW, H. & P. . . — Novæ fungorum species, XIV. (*Ann. Mycol., xiv, 256, 1916.*)

SYDOW, H. &. P. & BUTLER, E. J. — Fungi Indiæ Orientalis. Pars. V. (*Ann. Mycol. xiv, 177, 1916.*)

TUNSTALL, A. C. . . — Tea Roots, Pt. 1. (*Indian Tea Assoc. Pamphlet, No. 1, 1916.*)

,, . . — Fungi parasitic on the Tea plant in North-east India. (*Quarterly Journ. Ind. Tea Assoc., 1915, Pt. 3.*)

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BOTANY.

II.—ECONOMIC BOTANY.

III.—Mycology and Plant Pathology

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Agricultural Research Institute, Pusa.—The following is an account of the chief investigations at Pusa during the year.

Ufra of rice.—The investigation of "ufra," a disease caused by an eelworm, *Tylenchus angustus* Butl., was continued by the writer in collaboration with the officers of the Bengal Agricultural Department. During the year, it has been traced across the Megna into the districts of Bakerganj and Faridpur, as far as the borders of Kulna. Five districts, Noakhali, Tippera, Dacca, Faridpur, and Bakerganj, are now known to be infected, and extension is probably going on into Mymensingh, Kulna, and Sylhet.

Enquiries were directed to elucidate some of the anomalies observed in the parasitism of the worm. It has been confirmed that the spring or "boro" crop escapes, although often exposed to infection from a previously diseased "aman" or winter crop, and that, in general, the transplanted varieties are not attacked. It has been established that the "boro" crop, grown under irrigation during the dry months from January to April, avoids damage merely because the worms are unable, in dry weather, to leave the water to climb up to the susceptible parts of the rice plant, which are towards the top of the shoot. Experiments have proved that the worm can live for at least 8 months if fully dried and for much less—probably less than 2 months—if totally immersed, but that under such conditions it neither feeds, nor grows, nor reproduces. In very humid air, however, it moves readily outside the water, and it is only in really damp weather that migration to the above-water parts of the rice plant occurs, and that feeding and reproduction become possible. Hence the active life of the worm is confined to the period from June to November, when humidity is high, and for the rest of the year it remains quiescent or at most, if it reaches water, swims about for a few weeks without feeding or multiplying. Thus, though it is possible that there is some infection of the young "boro" seedlings in the first month after they are transplanted, no further injury can be caused once the dry weather comes, and the crop matures in safety.

In some areas, the period of active life may be prolonged into February, since there exist low-lying patches which do not dry out after the annual innundation until February, and a second growth of small shoots with dwarf ears comes from the winter paddy stubble in such spots. The heavy night dews of December and January allow of infection of this second growth, but by the end of February even it ceases to support the parasite. Leaving aside these areas, the broadcasted winter rice lands usually dry out in December, and the parasite remains quiescent in the dry stubble until the next crop is put in, in March or April. It then resumes active motion, but the experiments indicate that infection of the growing crop does not occur before May, when the rains usually break in these districts and humidity rises enough to permit of migration. By June, attacks on the maturing "aus" or autumn paddy are visible and by July they can be found in the still immature winter crop. They would doubtless be observed a month or so earlier, were it not that the symptoms of infection are not easily recognisable in immature plants and that, since multiplication does not begin much before June, the early attacks are usually mild. In transplanted paddy conditions are different. The transplanted rices (leaving out the "boro" and the rare transplanted "aus" kinds) are usually put out in August in relatively high fields. After harvest, these fields carry little stubble and are well cultivated as compared with the lower land. Experiments have shown that removal of the stubble is usually effective in preventing the disease and the few worms that may be left behind are ploughed in early and do not survive long. Occasionally a transplanted field becomes attacked (usually, no doubt, by spread from a neighbouring low field as the flood rises) but such attacks are rare and the parasite is not likely to survive until the new crop is put out in the following August. Hence the immunity of transplanted paddy is due to the relatively high level at which it is grown, to the more complete removal of the stubble at harvest, and to the early and thorough cultivation given to the fields in the spring.

Where the land dries out in December (as in most of the infected tract), the removal or burning of the stubble, combined with early cultivation, is the best way to combat the disease. This method has been entirely successful in a number of experiments carried on at Pusa and Dacca, and promising results have also been obtained on a field scale in several infected areas. In the low-lying patches, which do not dry out by the beginning of the year, it has failed. The failure is due to the difficulty in burning the wet straw and in cultivating the muddy soil so as to cause the debris to decompose. In such places, the worm has normally only to go through a month or two between death of the second growth from the stubble and the germination of the new crop. Hence early attacks occur, and each such patch serves as a focus of infection. To deal with these cases, experiments are being undertaken in two directions. Where a permanent water channel can be cut, the fields along its banks may be lowered and embanked so as to grow the immune "boro" crop; and where this is impracticable, the swampy patches may be drained so as to permit of early cultivation and stubble-destruction.

Other remedial measures being tried comprise the growth of early maturing kinds, which escape severe damage owing to their short growth period not allowing of much multiplication of the parasite; the encouragement of jute cultivation, with a view to establishing a rotation; the encouragement of transplantation; and the more extensive growth of cold weather crops. An account of the investigation to date has been prepared for publication. It is of interest to note that a second species of *Tylenchus*, agreeing in its main features with the peculiar mode of life of *Tylenchus angustus*, has recently been recorded attacking black currants in England, and it is probable that other cases will be found.

Orobanche on tobacco and Brassica.—Further experiments were carried out by Dr. Shaw with the object of testing the claim that sodium nitrate is a specific against this pest. The results of the previous season's work had been partly obscured by the fact that the amount of *Orobanche* appearing in a plot seemed to depend as much upon the degree of infection in the soil as upon the influence of any application of sodium nitrate. During the season 1916-17 the experimental plots were so arranged, in the light of the information gained during the previous season, that this factor was eliminated. It was then found that the amount of *Orobanche* which came up in any particular plot depended largely upon the degree of infection in the soil and was practically uninfluenced by any application of sodium nitrate upon an agricultural scale.

The species of *Orobanche* examined were *O. cernua* Lœfl, and *O. indica* Ham, and, as in the previous season, the former proved to be restricted to *Solanaceæ* while the latter occurred principally upon *Cruciferæ*, and only to a modified extent upon *Solanaceæ*. With a view to testing the parasitism of these species in greater detail than was possible within the limits of a field experiment, a series of pot cultures was carried out. Four host plants were used, namely tobacco, cabbage, mustard, and turnip, and these host plants were infected with seed of *O. cernua* and *O. indica* which had been collected from *Orobanche* parasitic both upon the species of host plant infected and upon the other three host plants. Thus pots containing tobacco plants were infected with seed of *O. cernua* collected from *O. cernua* upon tobacco, and with seed of *O. indica* collected from *O. indica* upon mustard, from *O. indica* upon tobacco, from *O. indica* upon cabbage, and from *O. indica* upon turnip. The same treatment was applied to mustard and to the other host plants. The results showed that *O. cernua* was strongly parasitic upon tobacco, and did not attack the other three hosts; while *O. indica* was not parasitic upon tobacco unless the seed used had been collected from plants which were parasitic upon this host, in which case such seed was not capable of infecting mustard plants. Seed of *O. indica* collected from plants parasitic upon either mustard, cabbage, or turnip, however, would not infect tobacco but was strongly parasitic upon all of these hosts. Thus there appears to be two races, or strains, of *O. indica*, one parasitic upon tobacco and not infecting mustard, and the other parasitic upon mustard, or the allied cabbage and turnip, and not infecting tobacco. Certain of the pot cultures received heavy applications

of sodium nitrate, which, however, did not have any marked effect upon the occurrence of *Orobanche* ; the details and results of all the above experiments are now in the press.

Phytophthora investigations.—Mr. Dastur has continued his studies on this important genus. The " Black Thread " disease of Para rubber trees is fully described in the " Memoirs " and, as a result, the attention of other workers has been directed to the similar condition prevalent in Ceylon and Java. It seems clear that the disease is found in most parts of the East where rubber is grown, but the Java workers still hold that it is due to the same parasite that causes rubber and cacao canker, and is not a new disease. Mr. Dastur has given reasons for believing the parasite to be a distinct species, a matter of considerable economic importance since the canker fungus is common especially in the neighbourhood of infected cacao trees. He has found the Black Thread fungus to be much more restricted in its parasitism than *Phytophthora Faberi* (the canker fungus) and has quite failed to get it to attack cacao and other hosts of the latter. The remedial measures recommended are being tested on a plantation scale in Burma. The chief are the free admission of light and air amongst the trees by judicious thinning and the cessation of tapping during the monsoon months on all diseased trees. In South India, where the same or at least a closely allied species is under investigation, good results have been obtained by the application of antiseptic and waterproof smears to the cut surface left after tapping. Tar and tallow ; sulphur, cowdung and clay, have been used, and no doubt other more efficient mixtures will be found. It is not yet certain whether similar measures will be required in the relatively drier parts of the Burma rubber districts and, at the time of writing, Mr. Dastur is carrying out further enquiries in Burma.

A second Memoir contains an account of a biologic variety of *Phytophthora parasitica* Dastur, found in Pusa on *Vinca*. It is a weak parasite, inoculations failing as a rule unless the atmosphere is almost saturated with moisture, but succeeding in damp air on a considerable number of garden plants. The fungus is, therefore, of more scientific than economic interest.

In a third paper, Mr. Dastur discusses the conditions influencing the distribution of *Phytophthora infestans*, the cause of the common potato blight. In India the fungus is ordinarily restricted to the Himalaya, Khasi, and possibly Nilgiri Hills, but periodical outbreaks have been observed in the Gangetic plain and the valleys of Assam and Sylhet. An analysis of the conditions leading to these attacks indicates that temperature, moisture, and source of origin of the tubers are all important factors in controlling the distribution of the disease. Long exposure to temperatures above 77° F. is already known to be fatal to the fungus, and such temperatures are usually found at the time of sowing the plains' crop. Furthermore, damp weather at the period of fructification of the fungus (January and February in the plains) is necessary to permit free reproduction and dissemination. And unless the tubers come from some already infected area, such as the Himalaya or Khasi Hills they are not liable to contamination and they will escape disease in the plains

since the plains' crop is normally free and local infection not usually to be feared. The outbreaks investigated showed that the seed used was probably infected, that it was brought from the Hills when the temperature below was under the normal for sowing time, and that the crop was exposed to rain or ground fogs as it ripened. Unless all these conditions are met, the crop may be expected to escape in the plains and in most of peninsular India.

Rhizoctonia and allied fungi.—Evidence was obtained that the jute disease caused by *Rhizoctonia* is associated, in severe attacks, with deficiency of some soil constituent, and the enquiry is being continued by Mr. Finlow, Fibre Expert to the Government of Bengal, who has obtained results pointing to potash as the constituent in question. Soil conditions are probably also concerned in the cotton disease known as "root rot" in northern and western India, which is frequently associated with the same fungus. The writer visited the Punjab in connection with this case. Dr. Shaw has continued his study of the sclerotial diseases of sugarcane and rice. At least three distinct forms attack sugarcane, one being identified as *Rhizoctonia destruens*, while the other two have not yet been named. One of these latter (or a very similar species) has also been found attacking rice, and all these, together with some other species obtained on various crops during the year, are being submitted to comparative study.

Anthracnose of Chilli and other crops.—The chilli disease at Pusa ascribed in last year's report to *Colletotrichum nigrum*, has since been determined, with the aid of the United States Department of Agriculture, to be due to a distinct fungus. The latter has now been identified with *Vermicularia Capsici*, already known in Madras, while the true *Colletotrichum nigrum* has been found recently in Burma. A third allied form, *Glomerella piperata*, occurs sporadically throughout India. It has been decided to restrict the name "anthracnose" to the diseases caused by the last two (which are doubtfully distinct) and to call the *Vermicularia* disease "die-back." Die-back is much the worst of the three, and experiments have been continued with a view to obtain a satisfactory treatment. Seed selection, from which much was hoped, has failed, but it has been found that one or two sprayings with Burgundy mixture at the end of the rains give good results. Further experiments are in progress. The same confusion in regard to the fungi causing anthracnose in pulses and *Solanaceæ* appears to prevail. *Vermicularia Capsici* has been found to attack these plants and to cause a disease resembling the anthracnoses to which they are also subject. Mr. Dastur is carrying out a detailed study of these forms.

Sal tree disease.—Dr. Shaw has continued his work on this disease, which appears to be causing increasing damage in north Bengal. The life history of *Polyporus Shoreæ* is being followed out in culture and its parasitism tested by inoculations in the forest. The work has not yet given definite results.

Miscellaneous.—Extensive trials of spraying against peach leaf curl were carried out near Peshawar by Dr. Shaw, in co-operation with Mr. Robertson

Brown, Agricultural Officer, North-West Frontier Province, the results being distinctly encouraging. Powdery scab of potatoes, caused by *Spongospora subterranea*, was recorded from Bombay for the first time in India. This is the first parasitic Myxomycete found in the country. The suspected cause of the soft rot disease of ginger has been isolated and its parasitism established not only on ginger but on chilli, tobacco, and other plants. It is a *Pythium*, allied to *P. gracile*. Several parasites of tea and coffee, not hitherto known to occur in India, were identified, amongst them being *Rosellinia bothrina*, *Sphærostilbe repens*, and *Cercospora coffeicola*. The writer has published an examination of the factors controlling the dissemination of parasitic fungi and of the legislative measures which may be applied to the protection of crops against introduced diseases. Two types of dissemination are distinguished, continuous or short-range and discontinuous or long-range. For the former, fungi are so well equipped that measures to check it are likely to prove abortive. For the latter, however, human activity as displayed in the moving of living plants from one part of the world to another, is by far the most important factor and is susceptible of control. A detailed examination of the history of many of the chief diseases of economic plants which have appeared in recent years, shows plainly that they follow the trade routes and are closely bound up with movements of living plants, conveyed by traders, botanists, and settlers. It is open to question whether the benefits thus gained are not outweighed by the losses caused through the introduction of disease. The application of legislation to the checking of this danger is discussed at length, with particular reference to the International Phytopathological Convention of Rome, drafted in 1914.

Other Scientific Departments.—The following are the chief items of mycological work carried out by other scientific departments, chiefly Departments of Agriculture.

Madras.—The following note has been communicated by Mr. McRae, Government Mycologist.

" The cultural work on *Ephelis Oryzæ* Syd. has been advanced, but the whole series of inoculations on paddy in the field this year has yielded no definite results. *Fomes australis*, a fungus produced on dead plants of *Coffea arabica*, has been brought into culture and has fructified in culture. The mycelium from a culture inoculated on the roots of *Grevillea robusta*, a common shade tree of coffee estates, infected them, but on the roots of *Coffea arabica*, *Acacia decurrens*, and *Zizypus rugosa* it did not on those examined, and the others have as yet shown no outward sign. Inoculations will be repeated during the rains. The fungus has also been found on orange trees that had recently died. The method of control of the fruit disease of *Capsicum frutescens*, caused by *Vermicularia Capsici*, is being worked out in the field. Bordeaux mixture, when sprayed evenly enough, prevents the fungus from attacking the fruits but, as the fruits are produced over a long period, spraying, to be effective, has to be done several times.

"The species of *Phytophthora* found on *Hevea brasiliensis* has been found to be parasitic on Hevea as a fruit-rot, a leaf disease, a die-back of branches, and a bark rot. The fungus lives through the dry weather as mycelium in the branches that have died back and as resting spores in the fruits. Experimental work with a view to check the fungus is being done this year on 350 acres of planted *Hevea*. Dead branches were removed after the flush of leaves developed, and fruits were removed before the coming of the rainy season. By inoculation, the fungus has been found to be parasitic on *Manihot Glaziovii* (Ceara rubber)."

Notes on some South Indian fungi of interest are published by Mr. McRae in the Year Book of the Madras Agricultural Department.

Mr. Sundararaman has contributed to the last-named publication a note on the common Sorghum smut, *Cintractia* (or *Sphacelotheca*) *Sorghi*. He estimates the loss at 10 per cent. of the crop in many districts and gives an account of its characters, mode of infection, and control. Copper sulphate, formalin, and hot water have all proved effective in seed disinfection and properly used will give a crop free from smut. For practical reasons he advocates the first named, used in 2 per cent. solution, the period of immersion of the grain being 15 minutes. He shows that this cereal is very resistant to copper sulphate, germination being unaffected by strengths more than sufficient to kill the fungus.

Mr. Anstead, Deputy Director of Agriculture, Planting Districts, carried out the following work in the Scientific Department of the United Planters' Association of Southern India.

The brown blight of tea, caused by *Colletotrichum Camelliæ*, has recently become prevalent on tea estates and has caused considerable damage, especially to nurseries. Hitherto it has been looked on as a minor pest and the conditions leading to its sudden virulence are not understood. It has been studied in co-operation with Mr. McRae, and recommendations for treatment made. In nurseries, it is recommended that as soon as the disease appears, all attacked leaves should be picked off and burned and the plants then sprayed with Bordeaux mixture. The nurseries should be kept open to light and air, free from weeds and fallen leaves and as dry as the plants will stand. Liming the soil is also advantageous. After the plants are put out as supplies or in new clearings, the same general measures are required. In old tea, when the attack is severe, prunings and fallen leaves should be burned, the ground limed at the rate of 5 cwt. per acre, rapidly acting nitrogenous manures avoided and phosphates and potash (or wood ash) applied. Very successful results have been obtained by these measures on an estate scale.

Grey blight of tea, caused by *Pestalozzia*, is often mingled with brown blight and can be controlled in the same way.

Coffee black rot (*Corticium Koleroga*) and leaf disease (*Hemileia vastatrix*) have also been attacked by spraying. The experiments have shown that the former disease can be successfully controlled with Bordeaux mixture combined

with regular pruning. Leaf disease, however, is more troublesome. If large areas, up to 100 acres or more, can be sprayed before the attack begins, the disease is lessened and after some years of regular treatment it would probably be reduced to negligible proportions. On a small scale, however, the sprayed patches are quickly reinfected from the untreated areas.

Experiments in the control of the *Phytophthora* disease of rubber were carried out in co-operation with the Government Mycologist. Four large plots were taken up in different localities in 1917 and various methods of treatment are being tested. No results can be expected as yet.

An attack by a species of *Glœosporium* occurred on a tea estate two years ago and caused a severe leaf-fall. It was treated by removing diseased and fallen leaves and spraying. Then the dead wood was pruned out, the soil cultivated, and lime and nitrolim added. This was successful at the time, but a new attack developed this year. It is uncertain whether the disease is a new one ; it seems to resemble in some respects a disease which does considerable damage at times in Assam but has not, as yet, been studied scientifically.

Mysore.—Dr. Coleman, Director of Agriculture, has published a bulletin giving the results of the preliminary investigations of the " spike " disease of sandal, a disease which threatens the existence of this tree in South India. After giving an account of the origin and spread of the disease and reviewing previous work, the author discusses the histological changes in the tissues of affected trees and notes the evidences of profound physiological disturbances in their metabolism. The chief of these is the presence of abnormal quantities of starch in the tissues. This feature has been correlated with diminished diastatic activity of the diseased, as compared with healthy, leaves, so that the starch formed is not sufficiently translocated. There is probably also an actual increase in carbon assimilation in the early stages of the disease, though the evidence on this point is not yet fully available. No parasite has been found, and the author inclines to the view that the cause is a virus whose active principle is an ultramicroscopic organism. The similarities between " spike " and certain other obscure diseases, such as " peach yellows ", are noted and experiments described showing that infection can be obtained by grafting a diseased branch on to a healthy stock, as in the last-mentioned disease. Infection by other means has so far failed. No evidence was obtained that external conditions of soil, climate or the like have any connection with the disease, beyond increasing its virulence, but it has been conclusively proved to be an infectious disease. How it spreads is not known, but diseased trees are a danger and should be promptly removed. This is the only recommendation that can be made at present.

Dr. Coleman's work on black rot of coffee, caused by *Corticium Koleroga*, mentioned in last year's report, has been written up and will be published shortly. A note on the fungi attacking green bug (*Coccus viridis*) will also, it is hoped, be issued soon.

Practical measures against areca palm diseases were continued. Considerable promise of success against the root disease (caused by *Fomes lucidus*) by trenching and liming heavily, has been obtained. The campaign against Koleroga (caused by *Phytophthora Arecæ*) has yielded excellent results. In one garden the disease has been stamped out, no case having occurred for two years; and others that have remained free under treatment for several years will now be left alone to see if there is any recurrence.

Bombay.—Mr. Ajrekar has continued the study of a disease of citrus trees associated with a species of *Nectria*. Inoculations with this fungus have so far failed. The disease was successfully treated by spraying with Bordeaux mixture and resin just before the rains. He has also attempted to establish a relationship between a *Sphacelia* which is parasitic on ears of jowar and a *Cerebella* found in the same situation. It is still uncertain however, whether the latter fungus is not merely a parasite or epiphyte on the former. Other research work by this officer included enquiries into a cardamom disease in Kanara, the connection between *Fusarium* and the scab of citrus (which recent work at Pusa has shown to be ordinarily a bacterial disease) and the life history of *Ustilaginoidea virens* on rice. The note on the use of copper sulphate in preventing sugarcane smut, referred to in last year's report, has been published.

Messrs. Ajrekar and Kulkarni have commenced the study of the rotting of stored potatoes. So far three rots have been distinguished: a dry rot due to *Fusarium*, another due to *Rhizoctonia*, and a wet rot, which is bacterial.

Mr. Kulkarni has completed and submitted for publication his study of the smuts of jowar (*Sorghum*) in Bombay. The fungi concerned are *Sphacelotheca Sorghi*, *S. cruenta*, *Ustilago Reiliana*, and *Tolyposporium filiferum*. A more detailed account of the work is deferred until next year. This officer has also continued the campaign against "Koleroga" disease of areca palms, 12,000 trees having been sprayed against 9,000 the previous year. A small plot has been taken up in Surat district for the selection of sugarcane against red rot.

Mr. Patwardan was in charge of operations against grape-vine mildew, and has commenced work against vine anthracnose. The operations have been extended from Nasik to Satara and continue to give very satisfactory results.

Central Provinces.—The work of this Department was carried out, in the absence of a mycological staff, chiefly in the direction of identifying diseases with the assistance of Pusa, and in isolating disease-resisting varieties of crops. Much damage was done to rice by *Sclerotium Oryzæ* and steps are being taken to find resistant varieties. Promising varieties of rust-resisting wheats are now being tested at Jubbulpore. The destructive fungus, *Cercospora beticola*, was recorded for the first time in India and the perfect stage of the peach rust obtained, also for the first time. Citrus diseases were

observed, the chief being an attack of *Rhizoctonia* on lemon seedlings and a disease of citrus stocks in the Nagpur nursery which may be due to *Phoma macrophoma*. "Foot rot" did slight damage at Tharsa.

Indian Tea Association.—Mr. Tunstall, the Mycologist of this Department, has continued his investigation of the root diseases of tea. He has succeeded in obtaining the perfect stage of one species of *Rosellinia* parasitic on this plant and also in obtaining material and cultures of the red rot disease, which permitted of the identification of the parasites at Pusa as *Rosellinia bothrina* and *Sphœrostilbe repens* respectively, both new to India and the latter new for tea. The former is prevalent in Darjeeling, but is not the only *Rosellinia* attacking tea in India. It can be checked in early stages by liming and clean cultivation. *Sphœrostilbe* occurs in stiff, acid soils and can be checked by removing diseased bushes and liming the soil.

A disease of tea stems in Darjeeling and the Terai has been found to be due to a *Nectria* which spreads from certain shade trees. It is a wound parasite of tea, entering at the wounds made by pluckers and extending down so as to kill the bush in two or three years. It can be stopped by pruning out diseased stems and applying lime-sulphur solution immediately. This treatment was successful on a large area in the Terai and is being widely adopted.

The practical methods of blight prevention received much attention but progress was slow, owing to the war. A scheme for general co-operative blight treatment was favourably received by the Darjeeling Planters' Association and experiments on a large scale have been arranged for.

Other work included observations on the dissemination of blister blight, experiments on the effect of general spraying treatment on the yield of tea, and an enquiry into the cause of deterioration of certain bheel gardens in Cachar and Sylhet.

SGPI—11 SBSA—3-4-18—50.

1918/19

BOTANY.

II.—ECONOMIC BOTANY.

III.—Mycology.

BY

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The following is an account of the chief investigations at Pusa during the year :—

Ufra of Rice.—An account of the investigations on the rice worm (*Tylenchus angustus* Butl.) carried out during the past few years by the writer, together with the field experiments and demonstrations in its control in which the officers of the Bengal Department of Agriculture collaborated, was published. Most of the results described have been referred to in previous reports.

Black band disease of Jute.—Dr. Shaw continued research work on this disease and carried out a series of field experiments directed to determine its mode of transmission. The attack in Bihar was less than in the previous year, probably because the dryness of the season in September led to a rapid ripening of the crop, which was mostly harvested a month earlier than in 1917. This did not give the parasite enough time to multiply seriously. Evidence was obtained that only stems of a certain size and maturity are susceptible under Pusa conditions and naturally this, if generally true, relieves much of the anxiety felt in regard to the attack on plants intended to be cut for fibre. On these it would be capable of causing great damage, as it possesses a cellulose-dissolving enzyme and will grow on pure cellulose in a solution of inorganic salts. But hitherto the bulk of the damage has been found on plants kept for seed. The examination of the fibre crop in several districts in Eastern Bengal in August and September, 1918, supported these results and also led to the observation that red-stemmed *Corchorus capsularis* grown at Dacca was only slightly attacked, while *C. olitorius* appeared to be immune. Artificial inoculations now in progress do not, however, suggest that the red-stemmed forms always escape. Temperature and humidity are probably controlling factors in determining the success or failure of inoculations on ordinary varieties.

The field experiments suffered considerably from the short monsoon of 1918 but suggested that the spread of the disease through spores adhering to the seed was not an important means of dissemination. If this is confirmed it may allow a relaxation of the seed disinfection measures at present adopted and which were applied last year at Pusa to the whole Bihar crop of the new selected varieties, amounting to some 40 tons of seed.

Sclerotial disease of Jute.—An interesting development took place during these investigations of jute diseases in the knowledge obtained regarding the sterile fungus referred to in previous reports as *Rhizoctonia Solani* Kühn. Dr. Shaw has discovered a spore stage which so far has only appeared on the infected living jute plant but which in artificial culture reverts to the sterile sclerotial condition indistinguishable from the form identified previously as *Rhizoctonia Solani*. Inoculations with the latter have regularly given the sporing stage. This appears to agree with a recently described Formosan jute parasite, *Macrophoma Corchori* Sawada. If confirmed an important step in advance will have been taken in the study of the Indian *Rhizoctonias*, of which the present is one of the most puzzling species.

Diseases of temperate fruits.—Work on these was continued by Dr. Shaw in Kumaon and Peshawar. In the latter district a successful method of controlling the destructive peach leaf curl has been worked out in collaboration with Mr. Robertson Brown and the current year's tests have continued to give most satisfactory results.

In Kumaon apple diseases are at present the most important and much work has been done on them. A large series of spraying experiments was carried out with varying success. Apple mildew is perhaps the most widespread of these diseases and some encouraging results have been obtained with strong lime-sulphur and with a mixture containing iron sulphide. Fly speck and sooty blotch (*Leptothyrium Pomi*) were reduced by lime sulphur. The disease caused by the fungus provisionally identified as *Coniothecium chromatosporum* is less readily controlled. Further work is projected.

Chilli diseases.—Work on these was continued by Mr. Dastur but was much interfered with by the dry weather which prevailed during the normal period of attack. There was so little disease that the field experiments gave scant results and they are being again repeated.

Pythium disease of Ginger.—The fungus causing the soft rot of ginger, damping off of tobacco seedlings and foot rot of papaya is fully described in a memoir by Mr. Subramanium now in the press. It is regarded as a new species, and is of interest owing to the variety of plants which it is capable of attacking. Potato, castor and chilli are amongst these.

Pigeon pea wilt.—A study of the cause of the remarkable differences in the severity of this disease in certain of the plots of the permanent manurial experiments at Pusa has been commenced by Mr. Finlow, Fibre Expert to

the Government of Bengal, and the writer. For several years past it has been noticed that there is very much more disease in the plots that have received mineral fertilisers than in those that have had no manure. As the plots are under very complete control and have been uniformly treated for the past eleven years they are unusually suitable for an investigation of this nature. Either the treatment of the plots has in some way altered the composition or characters of the host plant, or it has influenced the parasite, *Fusarium udum* Butl., a soil-inhabiting species. If the former, it should be possible to correct the deleterious action of the minerals by appropriate manuring, since the phenomenon is probably, in that case, nutritional. If the latter, it should be capable of detection by regarding the soil as a nutrient medium for the parasite. A new series of permanent experiments has been laid down to test the former of these views, while the latter is being attacked in pot cultures and by laboratory methods. It is hoped that the investigation will throw some light on the obscure problems of immunity and susceptibility to disease in plants.

Sugarcane smut.—Mr. Dastur has discovered the method of infection made use of by the fungus (*Ustilago Sacchari* Rabenh.) which causes this destructive disease. It is one that appears to be quite unique amongst the smuts hitherto investigated from this point of view. Entry into the plant takes place through the hairs on the young shoot-bud scales. Older buds can only be infected if wounded or injured. He has failed to secure infection through any other part tried.

Rangoon Bean blight.—Work on this disease was continued by Dr. Shaw, who visited Burma for the purpose. The responsible fungus is allied to *Sclerotinia*, and is quite distinct from *Phytophthora Phaseoli* Thaxt., which attacks *Phaseolus lunatus* in other countries. The severe outbreak in 1918 is attributed chiefly to improper methods of cultivation, and the improvement of these on the lines recommended by Dr. Shaw and the Burma Department of Agriculture will probably be effective in controlling the disease.

Miscellaneous.—Experiments in the checking of the rot of stored potatoes have been undertaken in the Punjab. The losses from this source, especially to seed potatoes, are very serious in many parts of India.

Dr. Shaw has continued his work on sclerotial fungi and on *Orobanche* of tobacco and mustard. *Nicotiana rustica* is not attacked by the latter at Peshawar, but the crop from Peshawar seed grown at Pusa was just as badly diseased as the local varieties.

A comparative study of the species of *Helminthosporium* on cereals has been commenced, while that of some *Phytophthoras* was continued. The latter work has strengthened the view that all the forms hitherto found on rubber in India and Burma are identical, but there is still some doubt about the Malayan species. Specimens of a *Phytophthora* which causes bud rot of coconuts in Jamaica were found to be identical with the writer's

Ph. palmivora, and this will probably lead to a re-investigation of the disease in other countries where it is at present almost universally believed to be bacterial.

Other Scientific Departments.

The following are the chief items of mycological work in other scientific departments, usually Departments of Agriculture :—

Madras.—Mr. McRae has published his work on *Phytophthora Meadii* n. sp., the cause of the destructive leaf-fall, fruit-rot and bark-rot of *Hevea* rubber. This important contribution to the knowledge of rubber diseases is based on work extending over several years and in part referred to in previous reports. The paper itself must be consulted for further details.

Another rubber disease has come into prominence and threatens to cause serious loss. From the description there is little doubt that this is the notorious "Brown bast" disease which has developed with such rapidity throughout practically all rubber-growing countries in the East and which is now occupying the attention of rubber mycologists almost to the exclusion of everything else. Its cause is still a mystery. Mr. McRae has carried out detailed histological observations on its effects.

The bud rot of the palmyra palm still continues in the Godavari and Kistna districts. A general examination of the palms was again carried out between December and March and the number of cases recorded. The diseased palms are treated by excision of infected parts. The total has fallen from 77,000 to 44,000 in the last five years, but the decline has been slow since 1917. The application of the recently passed Madras Pest Act will throw the onus of dealing with the disease on the owners of trees. At present they only do so when the Revenue Inspector visits the village. If this results in treatment as soon as symptoms appear, a greater number will be saved and the possibility of infecting healthy trees reduced.

The fungus *Thielaviopsis ethaceticus* Went from coconut palms affected with the stem bleeding disease has been under study. Inoculations on unwounded young palms failed, but when the fungus was inserted into a shallow hole in the stem it caused death. Older palms were successfully inoculated through wounds in only one case out of eleven tried. Treatment by cutting out the infected tissue and flaming and tarring the wound has given very good results; so far only three out of a hundred thus treated have shown a recurrence of the disease.

Blast of paddy, caused by *Piricularia Oryzæ* Br. & Cav., was wholly absent from Tanjore where it was epidemic last year. Slight damage was caused at Coimbatore. The parasite, or a closely allied species, was found causing an epidemic on *Panicum repens*, a common grass on paddy bunds. Wheat and barley have been successfully inoculated with the fungus from rice. At the Coimbatore Paddy Breeding Station the heavy yielding varieties

and individual plants are susceptible and the disease may prove a limiting factor in the production of heavy yielders.

Spraying of grape vines in the Salem district was repeated, oidium being treated in the dry season and anthracnose in the wet. In both cases the difference in favour of the sprayed plots was marked and about 30 per cent. more bunches were marketable from them than from the unsprayed plots.

Work on *Vermicularia Capsici* Syd. was continued and its range of natural host plants extended amongst the weeds of chilli field. There is little doubt that the fungus is carried over from crop to crop of chillies on these weeds.

Further experiments on treating the smut (*Ustilago Crameri* Körn.) of Italian millet (*Setaria italica*) confirmed the efficacy of steeping the seed in a 5 per cent. solution of copper sulphate.

Mr. Anstead, Deputy Director of Agriculture for Planting Districts, has co-operated with Mr. McRae in field work on diseases of rubber and tea. The experimental areas for treatment of *Phytophthora Meadii* McRae on rubber have been continued, but the light monsoon reduced the amount of disease. Removal of the fruit before the middle of June diminishes the disease, but labour is a difficulty. Cutting out all dead and dying branches in the dry weather, combined with pruning all those that hang down, has had a marked effect on an estate of 300 acres and is a more practical proposition. With pink disease (*Corticium salmonicolor*) experiments on a small scale in the use of Bordeaux mixture gave encouraging results and will be extended. Field work on "brown bast" is also in hand.

In tea, grey and brown blights are still prevalent, but can be effectively controlled.

Mr. Anstead is getting highly satisfactory results in the spraying of coffee against leaf disease (*Hemileia*) and black rot (*Corticium Koleroga*). Where water and labour are satisfactory the treatment undoubtedly pays.

Mysore.—In this State the Agricultural Department is carrying out research work on the spike disease of sandal, black rot of coffee and the root disease of the areca palm caused by *Fomes lucidus*. Field experiments to secure potatoes free from the ring disease have been continued. The campaign against Koleroga (*Phytophthora Arecæ*) is resulting in stamping out the disease in certain areas; at the same time attempts are being made to obtain a variety of the palm resistant to the disease.

Bombay.—The mycological staff in this Province consists of Mr. Ajrekar, who has also been acting as Economic Botanist, and Mr. Kulkarni. They have given much time to the study of potato diseases, especially the rots of stored tubers. The fungi causing dry rot (*Fusarium*) and black rot (*Rhizoctonia*) have been isolated and successful inoculations secured. Besides these, another form of injury, called black heart, is found, but is a heat effect and not a parasitic disease. Black rot is usually followed by the wet bacterial rot which completes the destruction of the tuber. Temperature seems to regulate

the ravages of this rot, temperatures above 30° C. favouring it while below 30° C. it develops but slightly. Powdery scab (*Spongospora*) is found in hill districts not only in Bombay, but also in Madras and Northern India, but so far has not been found in the plains.

Field experiments with red rot of sugarcane and smut of sorghum were continued, and the spraying work against Koleroga of areca nut was extended.

Amongst the other diseases studied were a new smut of ragi (*Eleusine coracana*), a withertip disease of onions and the mildews of chilli, mango and cumin. The mango mildew was found to be much more common on the inflorescence than previously suspected. Experiments in treating cumin mildew indicate the possibility of control by Bordeaux mixture sprayed on the crop when about a month and a half old.

The investigation of the *Sphacelia* and *Cerebella* on sorghum ears has established that these are distinct fungi and not stages in the life of a single species as at first suspected.

Bengal.—Work in this Province was practically restricted to the experimental treatment of diseases of mango, pine-apple, sugarcane, jute, mulberry and rice, carried out by Babu A. L. Som, Mycological Collector, Bengal Department of Agriculture.

Central Provinces.—Attempts to check cotton wilt by heating the soil and by a dressing of common salt gave no definite result nor did the treatment of infected soils with copper sulphate, sulphuric acid or superphosphate. A dry heat of 65° C. was found to be effective, but it is difficult to see how this can be applied in practice.

Indian Tea Association.—Mr. Tunstall, Mycologist to the Indian Tea Association, continued his investigations of tea diseases. A pamphlet on the disease caused by *Nectria cinnabarina* was published during the year. The branches die off slowly and the whole crown may wither, but a healthy new growth develops after collar pruning. The fungus was found commonly on fallen fruit stalks of *Pyrularia edulis* and *Alnus nepalensis* from which it is carried to the tea. Treatment with a lime-sulphur spray was quite effective.

Experiments were carried out to test the longevity of various fungi parasitic on tea. The common leaf parasites were found to survive throughout the cold weather if not exposed to the sun, but none survived exposure to the sun for four months.

A study of species of *Exobasidium* in the high-level Himalayan forests was commenced, eight species of plants being found to carry these fungi. Mr. Tunstall is inclined to believe that blister blight of tea (*Exobasidium vexans*) reached Darjeeling district through the higher ranges of the Himalaya.

[92.]

THE SECOND ANNUAL MEETING OF THE BOARD OF AGRICULTURE.

By E. J. BUTLER, M.B., F.L.S.,

Secretary to the Board.

The Second Annual Meeting of the Board of Agriculture took place at Pusa on January the 15th, 1906, and the following days, under the presidency of Mr. F. G. Sly, I.C.S., Officiating Inspector-General of Agriculture in India. The Board was attended by the members of the Imperial Department of Agriculture, representatives of all the Provincial Departments of Agriculture, excepting Burma, and of the Agricultural Departments of Mysore and Baroda, the Inspector-General of the Civil Veterinary Department, the Superintendent, Civil Veterinary Department, Bengal, the Director, Botanical Survey of India, and the Scientific Officer to the Indian Tea Association. The increase in the number of members (thirty-five in all) indicates the progress that is being made in the recruitment of the Scientific Staff of the Departments of Agriculture.

In his opening address the President described the action which had been taken on the recommendations of the Board in the preceding year. Of these recommendations the most important were the strengthening of agricultural staffs in India and the provision for publications by which the work of the departments should be made accessible to the public. At the first meeting of the Board, the difficulty of framing a definite policy of agricultural improvement and experiment in view of the scarcity of specialists available for the supervision of the work was acutely felt. Recommendations were made for the employment of additional staff in several of the more backward provinces and for the appointment of a number of special crop experts to deal with the problems presented by the more important crops of the country. Those which were particularly indicated were cotton, wheat, rice, jute, sugarcane, tobacco and fruit. The large provision for agricultural development announced in the last budget marks the first step in this direction. The Government of India have recommended to the Secretary of

State the creation of permanent posts for crop experts in cotton, wheat, tobacco, jute, indigo and sugarcane, as being the crops most likely to repay immediate investigation. The provincial agricultural departments have been, and are being, strengthened, and arrangements made for the founding of a Central Agricultural College and Experiment Station in every province. At these head-quarters a group of agriculturists and other scientific officers will work, while a number of subsidiary experimental and demonstration farms will be provided for every representative agricultural tract, in which the special agricultural conditions of each will be studied and the results of the work brought home to the cultivators. Thus for the first time in the agricultural history of the country a large and systematic attempt has been made to develop and improve, by the applications of science, its great industry under conditions which promise to be permanent and therefore ultimately successful. The agricultural publications of the past were severely criticised at the first meeting of the Board. As a result of its recommendations a considerable development in this very important matter has taken place. The issue by the Pusa Institute of the "Agricultural Journal," and of "Memoirs" for more scientific work, has been sanctioned by Government as an experiment for a period of three years. In the provinces arrangements for publishing the results of work accomplished on the experimental farms in a compact and easily accessible form have met with general approval. As at present suggested there will be an annual administration report of the provincial department which will contain an account of the general nature of the work which is being done. In addition, each experimental farm will distribute a more detailed account of its work to agricultural officers and others interested in experimental work. Finally, when a definite result has become established from a series of experiments, a separate bulletin containing a complete account of the work with its result will be published for general information. Work of other than local interest carried out in any part of the country will always find a medium for wide circulation in the Agricultural Journal.

In a number of other directions the recommendations of the first Board have been fruitful of results. Efforts towards the extension and improvement of Indian cotton, by hybridisation, selection and the introduction of new varieties into cultivation in India, have made considerable progress. In this Bombay has led the way. The introduction of Egyptian cotton into Sind and the hybridisation work elsewhere have already given much promise of future success. The question of extending jute cultivation outside Bengal is being fully investigated. In almost every other case the proposals of the first meeting of the Board have met with a favourable response.

The real business of the Board, which occupied the remainder of the meeting, included the framing of a standard curriculum for agricultural colleges, a review of the programmes of the departments of agriculture, discussions on the steps to be taken for the improvement of Indian wheat and tobacco, the use of commercial fertilisers in India and veterinary matters.

Sub-committees of the Board were appointed to prepare syllabuses in the principal branches of agricultural education. These were then correlated into a general curriculum for a course of three years' instruction. A feature of these syllabuses (which are published at length in the proceedings of the Board) is the value which is attached to practical instruction in the laboratory and in the field in addition to class-room lectures. The cultivation by individual students of plots on the college farm from an early stage is advocated, and also the training of the students from the very beginning in the ordinary processes of farming as practised on the farm. In the chemistry course the object in view is to bring the students into close contact in the laboratory with such matters as are directly related to agriculture. Qualitative and quantitative analyses are subordinated and the practical study of the properties of typical substances and their quantitative preparation substituted. Similarly in botany, entomology and veterinary science, practical work is given a prominent place all through the course. The object which is aimed at is to turn out students with such a general knowledge of agriculture in its main lines as will fit them for upper subordinate posts in agricultural departments, managerships of Court of Wards and private estates and similar positions. The conferring of a degree in agriculture of as far as possible, uniform value, to be recognised as equivalent to the B. A. degree, was further recommended.

The programmes submitted by members of the Imperial Department of Agriculture and by the different provinces were discussed at length. Arising out of this discussion the Board considered the lines of experimental and research work at Pusa. A sub-committee consisting of the Pusa staff and a number of the scientific and expert members of the Board drew up a memorandum in which the policy which they held should underlie the permanent experimental work of the Pusa Institute was outlined. In this memorandum the view is expressed that from the imperial character of the Institute the work should be of a broader and more fundamental nature than is usually carried on at agricultural experiment stations. The investigations should be devoted to general fundamental principles applicable to tropical and sub-tropical agriculture as a whole, and not be of merely local value. The latter should more properly be carried out at the local experimental farms in different parts of the country. The value of the former

class of work in scientific agriculture is brilliantly shown by the example of Rothamsted in England, where possibly the most instructive series of agricultural experiments ever devised have been carried out. Little or nothing has been done in tropical countries of similar scope. Pusa provides an opportunity for this work, and it will be possible to carry out investigations into the principles of tropical agricultural practice under conditions which provide for continuity and adequate supervision. Pusa will naturally be expected to undertake work of this sort, the provincial farms being in a position to carry on more detailed experiments of direct utility to local agriculture.

As indicating the direction which the experiments at Pusa are likely at present to take, the following may be mentioned. In Agricultural Chemistry plant nutrition investigations, particularly regarding the mode of transmission of food to the plant, including such enquiries as the movements of soil water, the availability of phosphate and potash in soils, and other large problems. In Botany the study of the principles which underlie plant breeding and plant improvement in India, permanent experiments in fruit culture, fibres and similar matters. In Mycology the investigation of soil fungi and their influence on plant nutrition and soils, and the study of specific plant diseases with a view to determining the *causes* which underlie parasitic attack and the *result* on the plant. In Entomology a general survey of the insect pests of the country and a study of the conditions of climate, soil and other factors governing their distribution and prevalence. In Bacteriology the influence of soil bacteria on plant nutrition in the tropics, the decay and fermentation of organic manures, soil inoculation with bacteria, fermentation processes in agriculture and the applications of bacteriology to the investigation of the method of plant nutrition in Indian soils. In addition to these main investigations there will necessarily be a considerable number of enquiries referred to Pusa from all parts of the country, soils, manures, food and oil cakes for analysis and report, botanical enquiries of various kinds, crop diseases and pests for identification and recommendations for treatment. Many of these less fundamental problems can gradually be dealt with by the provincial departments themselves, but particularly in the biological sciences Pusa will have to be in a position to advise and assist other workers in India, since it is at Pusa alone that the knowledge of the conditions prevailing in every part of the country can be concentrated and that collections permitting of the identification of agriculturally important plants and insects for the whole of India can be accumulated.

In considering the programmes of provincial departments of agriculture, some general principles were suggested by the Board as useful in laying

out farms and arranging their work. It is recommended that in farms attached to colleges the teaching portion of the farm should be kept quite distinct from the experimental. Other farms should be founded, each with some definite object in view in improving the agriculture of its particular tract. In some the object will be the study of a particular crop. A number of farms of this nature have already been started, such as those devoted to sugarcane at Samalkota in Madras, pepper at Taliperamba and ground-nut at Palur in the same province, tobacco at Rangpur in Bengal, tropical fruits and spices at Wahjain in the Khasi hills and others. In some, general problems connected with changes of cultivation or crops, irrigation, the reclaiming of bad lands and similar matters are more important. Seed raising is certain to be a very important branch of the activities of most departments, and this will require separate seed farms, some of which are already in existence. Demonstration work is another distinct section, one of the most important of all when the work begins to yield definite results, and separate demonstration plots, probably in large numbers, will be needed. In experimental farms the question of procuring greater efficiency and rapidity of tillage, and associated with this the improvement of work cattle and of cattle fodder, should be an important line of work. The sites for farms require to be selected with considerable care and to be tested by uniform cultivation to learn their peculiarities and to judge of their suitability for experimental work.

An account of the multifarious activities of the provincial departments of agriculture as submitted to the criticisms of the Board would take up far too much space to describe in this article. They may be found in detail in the proceedings of the Board and the reports of the departments. The mere enumeration of the work in hand with sometimes a very brief description of its nature occupies nearly twenty pages of an appendix to the Proceedings. One lesson has, however, been learnt in the past—that it is useless to attempt a large programme of work with an inadequate staff. The very attempt defeats itself, for supervision becomes impossible and the energies of the department become distributed over such a large field that little is ever really finished. A tendency to cut down work to a manageable size has become visible and will probably continue until the departments are better equipped. There is no doubt that this is a healthy sign of the more business-like spirit which has been infused into the work of agricultural improvement in recent times.

Certain general lines of agricultural work are prominent in the programmes of the more advanced provinces. In Bombay, Madras and the United Provinces for instance the study of individual crops has been

undertaken, in each case from the same general standpoint. The crops include sorghum, wheat, cotton, sugarcane, ground-nut, poppy and others. In each the first stage is the working out of the varieties grown in the provinces concerned, including a botanical classification, the determination of their agricultural characters and of their merits or defects and any other points of importance which may occur. In this way accounts of wheat and cotton have recently been published in Bombay, of sorghum in Madras and of sugarcane in the United Provinces. It is recognised that a reliable knowledge of the existing varieties is a necessary preliminary to much of the work of improvement.

Beyond this point the enquiries have not as yet progressed to any extent except in the case of cotton. But the further work which has been undertaken in the latter is probably an indication of what will be eventually done for many of the principal crops of the country. This work has been chiefly in the following directions First an attempt is made by hybridisation and selection to produce new varieties or to improve existing ones so that each climatic area may obtain a plant better suited to its needs than those already cultivated. In this, of course, attention is largely given to the class of lint produced by the new or improved variety. But it is becoming more and more recognised that in the economic state of the ryot it is useless to provide a superior staple unless the conditions which govern its suitability from his point of view, such as its hardiness, ease of cultivation, resistance to drought and cold are carefully borne in mind. It is useless to introduce a long-stapled cotton to replace a shorter, if the former is more troublesome to grow, less hardy, more liable to risk of loss in an unfavourable season and therefore in the long run less profitable to the cultivator. A larger profit does not in India, as it does often elsewhere, compensate for a greater risk, for it is only rarely that the cultivator has a reserve to fall back on. A second direction in which an attempt is being made to improve Indian cotton growing is so to alter local cultivation as to enable a more profitable variety to be grown or to improve the yield of an existing one. In some parts, for instance, cotton is being sown with irrigation before the rains, as by this means it is hoped that the better class of cottons may mature in Northern India before the cold season arrests growth.

Besides these two lines of work which can only be undertaken when a knowledge of the agricultural varieties of each province has been gained, there are several other directions in which improvement is being aimed at Seed selection and distribution is one of these. In the districts of Dharwar and Ahmedabad, cotton seed selected from the fields of cultivators sufficient to sow 11,509 acres was distributed by the Bombay department last year.

In several other provinces similar field selection of cotton seed has been undertaken. Seed of good varieties obtained in one part of the province has also been distributed to districts, where an inferior variety is grown. This has been done with a number of other crops, such as wheat, sorghum, and paddy, and one of the most successful of these attempts has been the introduction of Mozuffernagar wheat into the Eastern portions of the United Provinces. The trial of exotics, while not as a rule offering the same promise as the improvement of indigenous kinds, has in some cases been successful. In Sind some six thousand acres will be sown with Egyptian *Abassi* cotton this year, as this variety has proved suitable for irrigated lands and gives a good yield of lint, which has been valued at twice as much as the local kinds. Perennial cottons, both Indian and exotic, are being experimentally grown in several localities. Experiments in manuring cotton are in progress at a number of Government farms. Demonstrations of improved methods of cultivation for cotton have been made in backward parts of the Central Provinces and elsewhere.

The above is a summary gathered from the programmes of work of the departments of agriculture submitted to the Board, of the lines on which the improvement of a specific crop, cotton, is being attempted in India. What is being tried with cotton has commenced with several other crops, and eventually we may hope to see a number of the chief crops of the country systematically dealt with, and the direction in which improvement can be carried out determined. With two, wheat and tobacco, the Board have, in fact, drawn up a definite scheme for future work in view of the expected appointment of special wheat and tobacco experts.

The improvement of Indian wheat was considered largely from the point of view of the export trade. This has recently reached very large proportions, India having supplied more wheat to the United Kingdom in 1904-5 than any other country. Most of this wheat is used for bread making. No reliable milling and baking tests have, however, as yet been carried out, and the relative value of the varieties cultivated and the manner in which they compare with other wheats imported into the United Kingdom as bread-makers is not known. A survey of the varieties cultivated has been made in only a small part of the country, and this is the first step in the improvement of any crop. Indian wheats are often mixed, and a mixed wheat is unsatisfactory from the miller's point of view. There are difficulties connected with adulteration, storage, transport and other matters, all of which interfere with the export trade. As a result of the consideration of these points the Board adopted a scheme for future work, which should be a useful indication of the matters to which attention should be directed. They

suggest that in the first place a reliable survey of the varieties cultivated in each province should be made. This should include the general agricultural characters of the varieties, their distribution as regards area and type of soil, rust and drought resisting power, and suitability of the grain for local use and for export. In the second place milling and baking tests of the chief varieties should be made. Whether these should be carried out in a laboratory specially equipped for the purpose in India or should be done in England was left over for future consideration after the appointment of the wheat expert. Next the growth of pure varieties and the export of pure samples should be encouraged. The storage question should also be enquired into. Adulteration and transport difficulties are considered to be primarily matters to be dealt with by the trade. Finally a number of experiments, including the production of new varieties suitable for definite areas, introduction into cultivation of rust-resisting and drought-resisting wheats, seed distribution, rotation and other cultivation experiments and the like, are indicated.

In the same way a scheme was proposed for future work in the improvement of Indian tobacco. Certain areas are specified in which work may be most advantageously commenced. In these the existing methods of tobacco cultivation and curing should be enquired into, particularly with a view to ascertain the causes of the very different qualities of tobacco produced at different gardens. This enquiry should be supplemented by an investigation of tobacco soils and of the well waters used in irrigating tobacco to which the cultivators attach so much value. A comparative survey of the varieties should be carried out on the lines mentioned above in the cases of cotton and wheat. Experiments should be made in cultivation, methods of harvesting and methods of curing, especially the latter which offers the largest field for experimental work with the greatest possibilities of improvement. The trial of exotics should be one of the important lines of work. It is not considered that there is much scope for improvement in the production of tobacco in the form usually consumed by natives of India except by increase of yield, the main possibilities lying in the production of cigar, cigarette and pipe tobaccos.

Another subject which was considered by the Board was the use of commercial fertilisers in India. In some parts of India the time has arrived when there is a prospect of introducing this class of manures with good results. There is, however, often a difficulty in obtaining fertilisers of guaranteed quality. Suggestions for legislation for the inspection and control of commercial fertilisers were made and information concerning the systems in force in other countries was given. The Board resolved to appoint a committee to investigate the whole question and report to the next meeting, when the advisability of recommending legislation would be considered.

Many matters connected with agricultural stock and veterinary subjects were on the agenda sheet. Amongst these was the danger of restricting cattle-breeding by the curtailment of grazing grounds both by increased irrigation facilities, which have led to large areas being devoted to arable cultivation without any provision for grazing, and by closing forest reserves. A second matter was the consideration of the best method of employing the services of veterinary assistants, whether by stationing them at fixed headquarters or making them travel about their district. The provision of fodder in times of famine was also brought up for discussion. The Board decided that the issues raised by these questions are so large and the time given to consider them so limited that they should be deferred until the next meeting. The Government of India will be asked to request local Governments to collect information which will then be distributed to members well in advance of the meeting.

Before breaking up, the Board adopted some suggestions made by the President regarding the procedure to be followed in preparing the subjects for discussion at the annual meetings. It was agreed that the main subjects should be decided on as far as possible at the close of the preceding meeting in order to give members time to prepare the materials necessary for a full consideration of each. For next year the following programme was recommended : the confirmation of the proceedings of the last meeting ; consideration of the programmes of the Imperial and Provincial Departments of Agriculture ; a discussion on the improvement of sugarcane ; and the subjects referred over from the last meeting. Other subjects are likely to arise during the year. Finally it was decided to recommend to the Government of India that the meetings should be held alternately at Pusa and in the provinces, and it was suggested, at the invitation of the United Provinces Department, that the next meeting should be held at Cawnpore.

The above account will give some idea of the nature of the work done by the Board of Agriculture, and all its members feel that the annual meeting is a most useful institution, which affords an opportunity to the agricultural staff scattered throughout India of discussing their problems with each other, of correlating their work and of benefiting by hearing the views of others working for the same great object—the improvement of Indian agriculture.

THE THIRD ANNUAL MEETING OF THE BOARD OF AGRICULTURE.

By E. J. BUTLER, M.B., F.L.S.,

Secretary to the Board.

The expansion of Agricultural Departments in India, noted in the account of the second meeting of the Board of Agriculture (Agricultural Journal of India, Volume I, 1906, page 143), was still more evident at the third meeting which opened at Cawnpore on February the 18th, 1907, under the presidency of Mr. F. G. Sly, I.C.S., Officiating Inspector-General of Agriculture in India. Forty-six members attended as against thirty-five in the preceding year, the increase being more than accounted for by the presence of thirteen new officers appointed to the staffs of the Imperial and Provincial Departments of Agriculture during the year. Besides a very full muster of these Departments, the Board included the Inspector-General of the Civil Veterinary Department, the Director of the Botanical Survey, the Agricultural Chemist to the Government of Mysore, the Scientific Officer to the Indian Tea Association and the Directors of Agriculture of Baroda and Kashmir. The Board had also the pleasure of welcoming as visitors Sir Edward Buck, K.C.S.I., and Major E. H. Atkinson, R.E., Principal, Thomason College, Rurki, both of whom made valuable contributions to its proceedings.

The two previous meetings were held at Pusa. The new departure, of meeting alternately at Pusa and at one or other of the Provincial Departments' head-quarters, proposed by the Board in 1906, has met with general approval. As one of the main objects of the Board is to give to agricultural officers throughout India an opportunity of meeting together to learn something of

each other's work and to discuss their problems from the different stand-points induced by local conditions, it is felt widely that the advantage which will accrue from seeing the actual working of the departments in different provinces fully justifies the change.

The annual meeting of the Board of Agriculture is an occasion on which a review can be made of the progress of State-aided improvement in Indian agriculture during the preceding year. Though this is not an admitted function of the Board, which in its official discussions applies itself rather to plans for the future, it is still an inherent necessity of any such meeting, since it is impossible to discuss the future, without reference to the past. The opportunity has, indeed, been taken by the President at the last two meetings to refer briefly to the results during the year of the action taken on the recommendations made by the preceding Board. The programmes of work submitted by the Departments of Agriculture also contain frequent references to current work and to new lines taken up during the year. It is, therefore, possible from this point of view to gain a general idea of the activities in agricultural matters of the State departments concerned.

In attempting to give a brief review of the salient features of the year's work, as they can be gleaned from the Proceedings of the Board of 1907,* it is necessary first to make some reference to the organization of the Agricultural Departments in India, and the expansion of their staffs which has taken place in 1906-07. A very complete account of these Departments, with detailed lists of their staffs as they stood at the beginning of 1906, will be found in an article in this Journal on "Departments of Agriculture in India" by Mr. F. G. Sly (Agricultural Journal of India, Volume I, 1906, page 1). The Imperial Department as it stood in the beginning of 1906 has undergone

* Proceedings of the Board of Agriculture in India, held at Cawnpore on the 18th February 1907 and following days. Calcutta, Office of the Superintendent of Government Printing, India. Price, Rupee 1, annas 2; or 1*s.* 6*d.*

no considerable change. Five new officers were, however, posted to Pusa in the period under review, to receive a course of training intended ultimately to prepare them for responsible posts in the Provinces. The addition of these officers—known as Supernumeraries—to the different branches of Agricultural Science represented at Pusa, has become an important feature in the organization of the Pusa Institute, and every section has been, or will shortly be, strengthened by one or more junior officers. As vacancies arise, these will be posted to the charge of sections in the provinces.

The Provincial Departments have made a decided advance towards the organization outlined in Mr. Sly's article already referred to. A separate Department of Agriculture, distinct from the Land Records Department with which agriculture was previously amalgamated, has come into being in nearly all the provinces, and in each case is in charge of a special officer of the Indian Civil Service as Director of Agriculture. Each Department has obtained, or will very shortly obtain, a nucleus staff consisting, in most cases, of a Principal of the provincial agricultural college, a chemist, a botanist and one or more expert agriculturists. Entomologists and mycologists will not at present be appointed to any province, the whole of the work of these sections being for the present centred at Pusa, with the assistance of native staffs in the Provincial Departments.

The recruitment of the very large native establishments required has naturally been much hampered by lack of suitable trained candidates, but this is inevitable pending the completion of the agricultural colleges; the supply from them of well-trained men will eventually remove this difficulty. Besides the European staff of specialists mentioned, native assistants and subordinates are, therefore, being largely employed and will be graded into a regular service on rate of pay and prospects which will attract highly educated men who have been brought up among agricultural surroundings.

So much for the personnel. The material equipment has also an equally decided advance. The Agricultural Research

Institute at Pusa is approaching completion and it is anticipated that its laboratories will be occupied in the current year. In each province the site for the central provincial college and research station has been selected, and in most cases, considerable progress has been made in erecting the necessary buildings and laying out the land. Most of the provinces have been surveyed with a view to select suitable localities in which to found experimental farms, and the number of such farms in existence has largely increased. When completed, there will thus be besides the Imperial Research Institute at Pusa, eight provincial colleges and experiment stations, with full laboratory accommodation for scientific work, and a large number of experimental farms and demonstration plots in representative agricultural tracts throughout the country.

The degree of activity shown by the different departments naturally varies greatly in accordance with the staff available. In Burma, for instance, the Director was entirely without a scientific staff until nearly the end of the period under review. Several other provinces were but little better off. In Bombay, on the other hand, nearly the full staff was available. It is impossible to refer more than very briefly to a few of the directions in which the different departments have been active.

The work of the Agricultural Research Institute, Pusa, was outlined by a committee of the Board of 1906, who held that it should be directed, as far as possible, to solutions of the fundamental problems of tropical agriculture, the provincial departments undertaking more detailed or local work, of immediate application to local agriculture. Inevitable delay has occurred in inaugurating any large series of field experiments at Pusa, owing to the necessity of testing the soil of the different blocks. Uniform cropping for several seasons, so as to obtain a knowledge of their characters, has been the first requirement. When taken up in 1903, a large part of the present arable area was under jungle and all was in an unsatisfactory condition agriculturally. Hence, no field experiments proper have yet been commenced, and much time has been expended in mapping the farm into acre plots, the

yields of which have been separately weighed and recorded, so that a considerable amount of information as to the capabilities of the different fields has been acquired. Soil analyses of a very extensive nature have been made, and samples of all the blocks preserved for future comparison. It has, however, been possible to carry out a certain number of crop experiments in available portions of the farm, experiments in sugarcane cultivation, the testing of varieties, their period of maturing, behaviour to disease and so on, and the experimental cultivation of cotton and flax, being the chief of these. The ordinary work of laying out the farm has, of course, taken much time, but the necessary bunding, fencing, road-making, providing irrigation and so on, are now nearly completed, and it may be expected that permanent field experiments can very soon be commenced. The details of these are not, however, yet definitely settled, but it is safe to say that an important part of the experiments will be permanent series, something on the lines made famous by the work carried on at Rothamsted in England, but with special reference to sub-tropical practices and conditions.

In chemistry the work has included the determination of available plant food in soils. This has been carried out largely in the pot-culture house, a well-equipped structure which has been erected for work of this nature. The results obtained up to date will shortly be published. The amount of nitrogen compounds in rain-water and dew has been determined, in work extending over a year in each case. The published results show that the quantities, contrary to what has often been suggested, are no greater than those similarly found in England. The subject of soil drainage has also been taken up, with the aid of four drain gauges erected for the purpose. These are solid blocks of soil, cut out and underpinned without any disturbance, and they provide a means of collecting and examining the drainage water through different thicknesses of a measured area of surface. Other investigations of the quantity and movements of soil moisture have been carried on, and it is expected that some interesting data will be available for publication shortly. Similarly, an apparatus for determining the

quantity and character of soil gases has been perfected, with a view to obtaining information on this little known subject. Investigations have also been carried out on the conditions which lead to an accumulation of the cyanogenetic glucoside, which gives rise to prussic acid in certain plants, such as sorghum (*Andropogon Sorghum*) and linseed, (*Linum usitatissimum*) so often fatal to cattle, and on the value of the recently introduced artificial manures, calcium cyanamide and calcium nitrate.

In botany the chief work has been investigations in plant breeding and plant improvement. The determination of the varieties of Indian wheat has been taken up, a very large collection of the Indian wheats having been grown at Pusa and their characters studied, the almost invariable mixtures being separated into their component types. Similar work with barley and tobacco is also in progress.

A commencement has been made in wheat breeding work, a number of successful crosses having been obtained. The results which have attended this class of work in other countries hold out considerable promise for similar work in India, where little breeding has previously been attempted. The collection and investigation of certain fibre plants has also been commenced. The first step is to collect material for growing under uniform conditions, in order to determine whether the varieties of any particular fibre plant are true to type, and to isolate and examine the types. The value of these types will then be determined. *Hibiscus cannabinus* (*Patsan*) has been selected for immediate investigation. Other work includes a series of permanent experiments on the culture of Indian fruits, and the study of the varieties and cultivation of cassava, with particular reference to the amount of starch and prussic acid-producing glucoside present, the Agricultural Chemist collaborating in the latter investigation.

In entomology and mycology the work has naturally been of a somewhat different character. Since no provision for these sections has, at present, been made in the provincial departments, the acquirement of information regarding Indian insect and fungus pests of cultivated crops has necessarily occupied a large

proportion of the time of the sections concerned. The accumulation of collections and their identification, and the giving of advice to cultivators and others regarding their pests, form an important part of their work.

In entomology a staff of native assistants has been trained and posted to different provinces. These men are employed in field observations of the more serious crop pests and in urging on the cultivators the adoption of simple remedial measures. Slow but real progress in this direction is recorded, aided by the publication of a volume on "Indian Insect Pests," which may be expected to promote the spread of more common-sense views as to the origin and nature of insect epidemics. An attempt has been made to discover insecticides fatal to insects, but not, in the quantities used, to cattle or other stock. This has been carried out in collaboration with Mr. R. S. Finlow. The value of *trap* crops in preventing insect epidemics, the influence of climatic conditions on their prevalence, and the practicability of utilizing beneficial insects as a means of checking pests, were also enquired into at Pusa. Large reference collections are being accumulated and identified with the aid of specialists in Europe and America. The special investigations included an enquiry into the prevalence in India of biting flies which may act as carriers of disease. This is a subject which has reached great importance in medical and veterinary science recently. Little is known of the species which occur in India, and a comprehensive survey of them may prove of great value in the discovery of the causation of certain human and animal diseases. A severe epidemic of the cotton boll-worm has recently occurred in the Punjab and Sind. To combat this a large campaign was undertaken in the Punjab, the chief means adopted being the re-introduction of the natural enemy of the boll-worm, a parasite which, there is reason to believe, was killed out by the severe cold of the winter of 1905-06, the burning of stalks and refuse of the cotton plant in the fields, after the completion of the cotton picking season, and the planting of *trap* crops of *bhinda* (*Hibiscus esculentus*). The result was a distinct improvement in the crop in 1906-07.

In mycology the training of assistants for posting to the provinces has been started in a similar manner to that mentioned above for the entomological assistants. Little progress may, however, be expected from any efforts at present to teach cultivators to understand their fungus pests, for a considerable amount of education is required before the nature and effects of these obscure and minute parasites can be grasped. Attempts have, therefore, been made to indicate directions in which Government may take action in stamping out epidemic diseases and also to find disease-resisting varieties of crops subject to specific diseases. As an instance of the former, a large campaign has been started in the Godavari Delta to stamp out a very serious palm disease which threatens the extinction of palmyra and cocoanut palms in that area. This work is being carried out by the Madras Department with the necessary expert advice and assistance from Pusa. It is hoped, however, that in this case, material co-operation may eventually be secured from the ryots. The attempts to obtain a race of pigeon pea resistant to the wilt disease of this crop are promising well at Poona. At Pusa investigations of some of the chief diseases of sugarcane have been carried on, and a simple and efficient method of checking "red rot," the most serious disease of this crop, has been discovered. Research work has occupied much time, as a natural preliminary to the introduction of remedial measures in a country in which the crop diseases are largely uninvestigated at present. The collection and identification of Indian fungi is also a necessary preliminary to future work.

The work which is being carried out by the provincial departments, as submitted to the Board, is so extensive and varied that only a brief reference to its main features is possible here.

Efforts towards the improvement of Indian cotton are receiving considerable attention. The attempt to acclimatize Egyptian cotton in Sind has attracted much notice, not only in India, but in the markets of the world. There is no need to refer

at length to this experiment, the details of which are probably familiar to most readers from the columns of the daily press. The success of its early stages is promising, but consideration must be given to overcome the habits and traditions of the cultivators, which deter them from the labour and care required in growing these cottons, and the ravages of the boll-worm, before any considerable supply can become available. Egyptian cotton is also being grown in the South Western Punjab. A classification of Indian cottons grown at Poona and an account of some of the tree cottons have been prepared by Professor Gammie, Economic Botanist, Bombay. In Bengal and elsewhere trials of these tree cottons have been carried out, without, as yet, any definite success. Several hybrid cottons have been produced in Bombay and the Central Provinces and are being tested. In the Punjab, fifteen hundred acres were sown with acclimatized American cotton in 1906, and a substantial increase is anticipated this year. In the United Provinces a medium stapled American cotton has been acclimatized and introduced on a small scale near Cawnpore. Cotton seed selection is in progress in most provinces, the superior seed being distributed to the ryots. In the Central Provinces three farms are devoted to this work.

Wheat experiments, particularly in the introduction of improved varieties, are in progress in the wheat-growing provinces. In the Punjab some of the varieties introduced at Lyallpur have found much favour. At Cawnpore and Orai wheat-breeding work is being carried on, search being made particularly for a rust resistant wheat for Bundelkhand. In Bombay similar work has been initiated. At Hoshangabad in the Central Provinces wheat is under special study, and in these Provinces demonstrations on the advantages of saltpetre as a manure for irrigated wheat are being given.

In sugarcane the farm at Samalkota has done much good work in introducing new varieties into the Godavari Delta. This farm is devoted chiefly to the study of this crop. At Manjri, near Poona, sugarcane is also the chief crop and the

work of the farm has exercised a wide influence on surrounding cultivation. In Assam attempts are being made to popularize sugarcane growing. The Agricultural Chemist to the Mysore Government has made an enquiry into the industry in that State, and indicated several directions in which improvement in manufacture can be carried out. The Hadi process of sugar making is being taken up by cane growers in the United Provinces.

The improved cultivation of paddy, introduction of new varieties and experiments in transplanting and manuring are being carried out at several farms in Bengal, at Raipur in the Central Provinces and at Rajshahi in Eastern Bengal. The efficiency of *rab* is being tested at Lonavla in Bombay.

Tobacco cultivation and curing are being studied at Nadiad in Bombay, Dindigal in Madras and Rangpur in Eastern Bengal. New varieties have been introduced into Cocanada and Koilpatti in Madras.

The improvement of potato cultivation in the Khasi hills is one of the chief aims of the Shillong farm where new varieties are introduced, spraying for disease demonstrated and manurial experiments tried. Disease resistant potatoes are being sought for at Dharwar in Bombay.

Special farms have been opened for the study of groundnut at Palur in Madras, pepper at Taliperamba in the same Presidency and Tasar silk at Chaibassa in Bengal. Groundnut is also being studied on some of the Bombay farms. At Kanara spice cultivation is especially under enquiry. The tropical Garden at Wahjain in Assam is devoted to spices, drugs and tropical fruits, while temperate vegetables and fruit are being acclimatized at Shillong. Rubber, fibres and a number of exotic and Indian economic plants are receiving attention at Ganeshkind Gardens in Bombay, where also there are experiments in fruit growing. A new economic garden for similar work has been opened at Bassein on the sea coast north of Bombay.

At most farms in all the provinces there are experiments in cultivation, manuring, seed-rate, introduction of varieties and

similar questions, with a large variety of crops, including most of the staple crops of the country.

Seed farms for the supply of good seed of cotton, wheat, jute and other crops have been opened in several provinces.

Of special enquiries mention should be made of the *reh* or alkali land investigations in Sind, the United Provinces, and the Punjab. Efforts at reclaiming alkali land by the application of gypsum, by drainage and by washing out the salts are in progress. In the United Provinces a survey has been made to locate sites where wells may profitably be constructed and a special well-boring staff entertained to conduct trial borings. In times of scarcity the assistance of Government for these minor irrigation works has been secured, according to a definite programme. A scheme for a similar survey has been prepared for the Punjab. Investigations of questions of soil nitrogen, determination of seepage in field irrigation channels, soil inoculation of leguminous crops and studies in insect and fungus pests are carried on at Cawnpore. Studies of root parasites, especially the sandal tree, and a survey of the wild peppers of the Presidency have been carried out by the Government Botanist, Madras. The co-operative system of seed distribution which has been devised in the United Provinces has been described at length in the present issue of this Journal.

Besides the general agricultural work of the departments, mentioned above, several important crops have been made the subject of investigation by special officers appointed for the purpose. These are indigo, tea, jute and other fibres. The Indigo research station of the Behar Indigo Planters' Association receives a subsidy from the Bengal Government and is under the charge of the Imperial Bacteriologist who has been lent from Pusa for the purpose. The nature of indigo fermentation has been investigated and several improvements in manufacture carried out. The station has also been concerned in the extension of the Natal plant, which has revived the indigo industry, moribund under the competition of artificial or synthetic indigo. Recently a series of dying tests has been carried out which indicates a marked superiority of the natural over the

synthetic product. A large number of other investigations connected with seed raising, improvement in germination of Natal seed, cultivation, trials of varieties and other questions have been carried out.

The scientific department of the Indian Tea Association is under the charge of a special officer appointed by the Association and maintains an experiment station at Heleeaka in Assam. It receives subsidies from the Governments of India, Bengal and Eastern Bengal and Assam. During the period under review investigations have been carried on on the fermentation of tea, the causes which influence "quality," the characters of the tea soils of North Eastern India, several insect and fungus pests of tea (including the mosquito blight, red slug caterpillar, blister blight and red rust) and questions of manuring and cultivation. The value of the work of this department has received wide recognition from the tea industry.

Attached to the Eastern Bengal and Assam department is a special Fibre expert, whose work has been chiefly connected with jute. A survey has been made, as a result of an extensive tour, of the districts in India which appear to offer promise of success in jute cultivation. The extension of the area under jute is one of the first needs of the industry at present, as an increased demand has led to fraudulent watering on an extensive scale and the supply of inferior grades of fibre to the market. Experiments were carried out to determine the quantity of moisture naturally taken up by jute fibre under different conditions, in order to provide a basis for legislation should it be needed. Retting experiments were also carried out. Field experiments on the best season for sowing and thickness of planting are in progress and trials of a number of other fibres, possible substitutes for jute, have been made. Selection experiments with jute, designed to improve both the quality and yield of fibre, have been commenced and will form an important part of future work.

The consideration of the programmes of different departments, from which the above abstract has been made, occupied the first two sittings of the Board. The remaining three days

were devoted to the discussion of several matters of general interest to all the departments.

The chief of these was the improvement of the Indian sugar-cane industry. The available statistics show that the consumption of sugar in India is increasing, while there is no corresponding growth in the area under cane in the country. It is everywhere recognized that, though India possesses canes, the quality of which is not surpassed in any country, still the yield of raw sugar per acre as a whole is lower than in any other sugar producing country. A scheme was prepared, after prolonged discussion, of the directions in which improvement can be attempted, and was adopted as a general guide to the departments of provinces in which the crop is of commercial importance. This scheme is contained in the published proceedings and need not be further referred to here.

Arising out of the grant of £10,000 made by the British Cotton Growing Association, the Government of India requested the advice of the Board regarding the best plan for assisting cultivators in disposing of small quantities of any new fine stapled cotton introduced into cultivation. The Board recommended that the direct intervention of Government should be restricted to the earlier stages of any such introduction. In these early stages it may be advisable for Government to purchase the produce. Later on, when the area commences to expand, the assistance of private firms acting independently or as Government agents may usefully be sought. With still larger areas Government auctions, such as those held in Sind to dispose of the newly introduced Egyptian cotton, are recommended.

The question of legislation for the control of artificial fertilizers, brought before the Board of 1906, was again considered; the Board decided from the evidence collected in the meantime that the time is not ripe for the introduction of such legislation, though it is desirable to maintain a special watch over the developments which may occur in the future in this direction.

Sir Edward Buck gave addresses on two important questions which led to interesting discussions. The first of these was the utilization of river silts in India. The quantity and nature of

these silts is under investigation by the Imperial Department of Agriculture and by the Geological Survey. Their agricultural value was testified to by a number of members present, and the discussion elicited many facts of general interest in this connection. The Board agreed that it is a grave error not to utilize fertilizing silt wherever it may profitably be used, and recommended that silt investigations should be continued and extended, and that the co-operation of the Irrigation Department should be sought in the enquiry. The second matter brought up by Sir Edward Buck, was the employment of Agricultural Engineers in India. He instanced a number of important enquiries in which the services of trained engineers could profitably be utilized. The work which has already been done in such directions as well boring, lifting well water by power, checking erosion and carrying out minor irrigation work, though on a small scale, was appreciatively referred to by several members. As a result of these indications Major Atkinson, R.E., Principal of the Thomason College, Rurki, explained to the Board the technical qualifications required for such posts and the training necessary for the subordinate staffs. The Board recommended the question to the earnest consideration of local departments.

Of veterinary matters the chief considered was the provision of fodder in times of famine. A number of suggestions were made in this connection, and the Board recommended them for the consideration of the local departments.

The above summary of the matters considered at the Board of Agriculture of 1907, gives some indication of the work of the different departments and special officers. If it is remarkable rather for the amount of experimental and research work projected than as a record of improvements actually accomplished, this is partly accounted for by the fact that the Board occupies itself, as already said, more with the future than the past. It is also, however, in a large measure due to the recent birth of systematic agricultural enquiry in India, and it cannot, I think, be denied that the infant departments show remarkable signs of vigour and that their future careers are full of promise.

THE FOURTH ANNUAL MEETING OF THE BOARD OF AGRICULTURE.

By E. J. BUTLER, M.B., F.L.S.,

Secretary to the Board.

The fourth meeting of the Board of Agriculture was held at Pusa from the 17th to the 22nd February 1908, under the presidency of Mr. J. Mollison, Inspector-General of Agriculture in India. It was attended by fifty-one members and seven visitors, an increase over even the large attendance of last year. These numbers were made up of the members of the Imperial Department of Agriculture; the Directors of Agriculture of each province except Bombay and several members of the expert agricultural staff of each; representatives of three Native States' Departments (Mysore, Baroda and Kashmir); the Director-General of Commercial Intelligence (Mr. Noël-Paton); the Director of the Botanical Survey (Capt. Gage); the Reporter on Economic Products (Mr. Burkill); and the Scientific Officer to the Indian Tea Association (Mr. Hutchinson).

The subjects for discussion were varied. Besides a consideration of the programmes of the different Agricultural Departments, they included practical questions such as the best means of bringing the work of the Departments home to cultivators, the extension of fibre cultivation in India and poultry breeding; educational questions such as the best course of studies at Pusa and at Provincial Agricultural Colleges; and administrative matters such as the constitution of the Board of Agriculture, the form of its Report, and the staff required in certain sections of Provincial Departments, with the rates of pay necessary to secure good men for the upper subordinate posts.

In the programme of the Imperial Department of Agriculture it was pointed out that the scientific staff of the Pusa Institute will be for the first time complete and will consist of fourteen European officers, with a full complement of Indian assistants. The Institute laboratories will be finished and occupied this year, affording much needed relief to the staff, who have been working up to date in ill-equipped temporary buildings. The farm is now practically all under cultivation or pasture, and it has become possible to commence permanent field experiments on land whose capacities are fairly well known. Three considerable series of manurial, rotation and pasture experiments were approved by the Board and have been commenced.

Besides these permanent experiments, which are regarded as being of the first importance, the work of the Agricultural section at Pusa proposed for the current year includes experiments with important crops, such as sugar-cane, flax and other fibre crops, tobacco, wheat, rice, maize, opium and castor, and cattle, sheep and poultry breeding.

In the Chemical section the chief subjects under investigation are the available plant food in soils; the nature and amount of substances which are removed by drainage; the factors controlling the movements of soil water; the amount of water required by various crops; and chemical investigation connected with the permanent field experiments at Pusa.

In Mycology the study of a number of crop diseases will be continued and new ones taken up. As this section, in common with that of Entomology, is intended to deal with work in all parts of India (there being no expert mycologists or entomologists on the staffs of Provincial Departments), a considerable amount of time is taken up with tours for the investigation of crop diseases. The preparation of a text-book on Indian Agricultural Mycology is in hand.

In Entomology, besides continuing the work of studying and advising on crop pests, the experimental cultivation of lac and of eri silk will be continued, and other wild silks taken

up. Other enquiries include the investigation of insecticides non-poisonous to cattle, the study of insect-eating birds and methods of checking pests of stored produce. Tours to investigate local pests or to deal with outbreaks of injurious insects will be undertaken. The second Entomologist will be engaged in the study of biting flies and of dipterous pests of crops. It is hoped to bring out a book on Indian insects during the year.

In Economic Botany, work on plant breeding and plant improvement will be continued with wheat, tobacco, cotton and barley, as well as other important rabi and kharif crops. A monograph on Indian wheat will be completed. The permanent experiments on the culture of Indian fruits will be continued, and also the collection and investigation of fibre-yielding plants. Other work includes the study of Cassava as a famine food-stuff (with the Imperial Agricultural Chemist), and the economic importance of the male plant in *ganja* cultivation.

In Provincial Departments the main lines of work in progress were referred to briefly in the account of the Third Meeting of the Board of Agriculture published in this Journal last year. * Nearly all are adding to their existing experimental farms or getting those recently taken up under cultivation. Several of the new stations are intended for special work, such as those at Partabgarh in the United Provinces for sugar-cane, at Daulatpur in Sind for alkali reclamation, at Chaibassa in Bengal for Tassar silk, and at Burirhat in Eastern Bengal for tobacco. Most of the older farms are engaged in more general work, as described in the review of last year's meeting, and an account of their work, and of the very varied activities of Provincial Departments, would take us far beyond the limits of the present note.

One of the chief functions of the Board is the detailed examination of these programmes with a view to suggesting improvements from the combined experience of agricultural officers in different Provinces, to prevent overlapping and to secure co ordination where this is necessary. It was felt that

* *Agricultural Journal of India*, Vol. II, p. 224, July, 1907.

this function is not easily fulfilled by the full Board, and a recommendation was made, which will probably be followed in at least the alternate years when the meetings are held at Pusa, that the programmes should be submitted to expert sub-committees before being presented to the Board.

The constitution of the Board itself came under discussion in response to a reference from the Government of India. The number of members has grown year by year until it has reached unwieldy proportions. It was recommended that the number be curtailed to 38, made up of 11 Imperial and 27 Provincial and non-official members, six of whom should be nominated each year by the President, and four elected by the provincial expert staff. In addition, it is hoped that, in alternate years, when the Board meets at Pusa, all members of the Agricultural Departments in India (including Native States with such departments) will attend, where possible, as visitors, though not as official members.

The improvement of Indian poultry has been consistently advocated for years by Mr. H. Abbott, Editor of the "Indian Fowl Fanciers' and Farmers' Journal." Largely as a result of his efforts, the subject was included amongst those set down for discussion at the recent meeting, and he was invited to attend. Some remarkable figures were provided of the development of poultry-farming in the United States in recent years. By the census of 1900 the number of birds on the farms from which returns were secured was over 250,000,000, and the year's produce in birds and eggs amounted in value to more than £56,000,000, probably exceeding any single item of the farm produce of the United States. The Indian *moorghi* is notoriously degenerate, and the supply besides is by no means equal to the demand, with a resulting steady rise in price. To improve the industry Mr. Abbott holds that Government assistance, both in advice and in provision of improved breeds, should be given to native professional poultry breeders. In addition, a strong effort should be made to extend poultry-breeding through all useful agencies in India, such as agricultural

experiment stations, grass farms, missions, European planters, Eurasians and well-to-do Parsees and Mohamedans. While endorsing much of what Mr. Abbott said, the Board considered that the results of the preliminary work now being carried on at Pusa should be awaited before any large attempt to extend the industry through Government agency was entered on. Should these experiments show that the breeding of improved poultry gives promise of becoming a remunerative industry, the Board recommended that the work should be extended through the above-mentioned agencies, and indicated generally the varieties likely to prove most suitable for breeding purposes, and some of the important points requiring attention in the care of poultry in India.

The effect of the extended cultivation in India of fibre plants other than cotton and jute on the material prosperity of the country and the best lines for future experimental work in this direction were discussed by a sub-committee. Their report indicated that the time allotted for its consideration was inadequate for so large a matter. It was decided to collect whatever information was available in each Province, and the President, together with the members of the sub-committee, were asked to arrange for the publication of a consolidated report in pamphlet form.

As the educational side of the work of Agricultural Departments in India will soon be fully organised, and there will shortly be available seven Agricultural Colleges in the Provinces, besides the college for higher instruction at Pusa, the courses of instruction to be provided at these colleges were again considered. In 1906 the Board provided a draft syllabus for Agricultural Colleges. This was now revised in certain details in the light of the experience gained by officers of the Department during the intervening period, and arrangements made to print it separately for distribution to those concerned. It is intended to serve as a basis on which Provincial Colleges will be able to arrange their courses of instruction, but it was recognised that a moderate amount of expansion or reduction may be necessary in individual cases to suit local requirements.

The greater part of the discussion ranged about the degree to which practical training might precede theoretical instruction. On the one hand, it was held that since the majority of the students will be deficient in regard to a general education sufficient to enable them to understand readily the principles of good agricultural practice, it should be recognised that the courses will fall into two groups:—(1) subjects taught for their educational value; (2) special subjects directly connected with agriculture. Since agriculture may be regarded as an art based on several sciences, the subjects under the 1st group are taken to be the sciences on which the art of agriculture is founded; and it is contended that these subjects should be taught in such a way that the main object of a sound education may be achieved. These subjects are Chemistry, Physics, Botany, Zoology, and Mathematics. It was held by several members that no sound teaching can be given in the second class of subjects until at least a good basis is laid in the first. Hence, in the first year only these subjects should be taught, and in the second year special agricultural training may be commenced.

Opposed to this was the opinion of the majority of the Board, that practical training in the field should be undertaken at the very start. The arguments in favour of this view were almost entirely of a practical nature, with particular regard to the character of the students who would attend Indian Agricultural Colleges. Many of these are disinclined by upbringing and tradition to themselves actually handle field implements. These are amongst the better class students whom it is hoped to attract for training to fit them for managing their own estates or to become managers of other estates or assistants in Agricultural Departments. It is recognised by all that sound agricultural training is impossible, unless the actual processes of agriculture are carried out by the individual student for himself; the introduction of practical field work at the start impresses this on the student's mind and serves to weed out those who will not, for this reason, profit by their training. A further reason for commencing practical work at the earliest opportunity is the leaning of the Indian

mind towards the abstract rather than the concrete; it is feared that theoretical instruction, too exclusively followed at the beginning, may deflect the attention from the end of the training, which is to improve agricultural practice, and may lead to a neglect of the art in the study of the science of agriculture.

With regard to the class of instruction to be provided at Pusa, it is recommended that this should consist of post-graduate courses for students who have already passed through a Provincial Agricultural College, and for other selected students who, by reason of their education in science, are likely to derive real value from the advanced courses. These courses should, it is suggested, be provided for the following:—(1) students intended to become assistants to provincial experts in Agriculture, Agricultural Chemistry, and in particular Economic Botany, Mycology and Entomology; (2) students sent for special purposes. Courses of instruction on these lines will be prepared at Pusa and submitted at the next meeting of the Board for approval.

A prolonged discussion took place on the rates of pay and prospects required to attract the right class of men to the subordinate staff of Agricultural Departments. The more senior members of the Board were practically unanimous in holding that the present prospects were insufficient to attract good men. The suggested rates, however, differed in the different Provinces, though the majority held that the Provincial Executive or Revenue service should serve as a standard. The Board finally suggested that the prospects for the upper subordinate staff should be made somewhat better than those of the Provincial Executive Service, in view of the fact that the service is new and specialised, but was not in a position to suggest the number of posts or particular grading required in each Province.

In connection with the recruitment and training of the requisite Indian staff, a discussion took place on the lines on which mycological and entomological work in the Provinces should be conducted. In these subjects no European specialists are engaged outside Pusa. It was recognised that the research

work should be done as far as possible at Pusa, and that Provincial work in Mycology and Entomology should be limited to the employment of a special staff (1) to give such assistance to Pusa as is required for this work and (2) for the elementary training required at Colleges. The practical field work for the prevention of pests and diseases should be undertaken by the ordinary staff of agricultural assistants. The Provincial Economic Botanist should control the mycological teaching at Provincial Colleges.

Probably the most important subject considered at the meeting was that of the best methods of bringing the work of the Departments to the notice of cultivators. In India the attempt is being made to influence the mass of the people and to bring about a gradual improvement in the industry by which the majority subsist, by working from the top downwards. It is self-evident that this attempt will succeed or fail according as the Department of Agriculture wins or fails to win the confidence of the cultivators. Could the country afford to await the spread of primary education, the work of the Department in this direction would be much lightened; this is for many reasons impossible, and the departmental officers have to face the fact that they must deal with a class whose needs are often obscure or inarticulate, who are prone to distrust official interference, who are shy of the European and whose conservatism, though sometimes exaggerated, is very often a decided bar to suggested improvements.

It has been recommended that year by year an account should be furnished to the Board of Agriculture of the efforts of the Departments in the different Provinces to reach the cultivators, and of their results. The first of these reports was drawn up at the recent meeting, and, besides being included in the Proceedings, will be separately published for general information. It deals in succession with the methods employed or suggested by the several Departments, premising that each is adapted to special conditions. The following are amongst the chief of those dealt with :—

Agricultural Associations.—The formation of local associations for agricultural improvements has been one of the most common methods of increasing interest in the work. There has been a good deal of discussion as to the value of these associations, and so far it may be said that no two Provinces have had quite similar experiences with them. This seems to have resulted chiefly from two causes : first, the personal touch maintained by the officers of the Agricultural Department and the prominent members of the Association with the cultivators ; second, the extent to which the Department has as yet had real improvements of proved value available for introduction. The closest personal touch can be maintained in small associations, such as village or taluka associations, but for this a considerable number of trained officers of the Agricultural Department is required, and these are not yet available to any large extent, nor is there probably sufficient confidence in the Department to make them a success. Hence the future of the small associations is bound up with the Agricultural Colleges, and it is not until these have turned out a large number of reliable trained assistants and inspectors that any great development in this direction can be attempted.

In some Provinces, District Associations with the Collector as Chairman have been successful. As the number of these is limited, the superior officers of the Department are able to attend the meetings (held half-yearly in the Central Provinces). The utility of these depends largely on the presence of a body of substantial men who are also cultivators, and on the engagement by these to carry out definite pieces of demonstrational work proved by the Department itself as likely to succeed.

It is in the provision of definite demonstrations of proved value that the second difficulty is likely to arise at the present time. So many variable factors arise in agricultural practice that progress must necessarily be slow and the departments are still very young. The introduction of a new crop or variety, or of a manurial practice, though fully tested at an experimental farm, may fail, unless the farm is exactly representative of the tract.

The cost has to be very carefully calculated or a new method may be beyond the reach of the small cultivator. Errors in the management of the demonstration are only too likely to occur. In India, agricultural change must usually follow economic change, not lead it. The extended cultivation of poor hill soils which will grow tapioca was brought about in Travancore by the rise in the price of grain, driving the poorer classes to find a substitute; without this incentive it would probably never have occurred. Similar cases could be multiplied, and it behoves the Departments to be ready to meet a demand as soon as it arises, as well as to endeavour to create a demand for new improvements.

Speaking broadly, then, the two things on which the success of Agricultural Associations in bringing about direct improvement depends, would appear to be confidence in the advisers, leading to their advice being carefully followed, and the provision only of carefully considered and tested improvements for demonstration, with arrangement for efficient management. Failure to secure these may, most likely will, result in failure of the demonstration; the confidence of the small cultivator will be shaken, and the result, with a distrustful and sceptical community, will be deplorable.

Demonstration Farms.—Similar to the demonstration work of the Agricultural Associations, only more directly under Departmental control, is the work of these farms. They have not yet been developed largely, except in the Central Provinces, but if the above-mentioned dangers are avoided, they appear to give considerable promise of success. With the associations they are bound to take a prominent place in any arrangements for the provision of good seed. This work is at present carried out by a limited number of seed farms, or by seed depôts, such as those described in this Journal, Vol. II, p. 217, in Oudh; it cannot be doubted that, in the absence of professional seedsmen comparable with those of Europe and the United States, a large development of Government work in this direction is inevitable. With such a development the utility of the demonstration farms will

Village Agencies.—These are employed chiefly for the purpose of introducing improved implements. The agent controls the sale or hire of implements received through the Department. Repairs are arranged for by periodical visits from workmen of the Department.

Publication of Agricultural information in the Vernacular.—Several vernacular agricultural Journals are published by or under the patronage of the Departments. In the Central Provinces the monthly departmental paper has a circulation of 2,500. Better results are thought to be obtained by encouraging and contributing to privately owned vernacular agricultural Journals. For the higher English-speaking strata, the *Agricultural Journal of India* should be sufficient to meet requirements and the Provincial Departments should aim at reaching cultivators and landowners through vernacular journals. Many of the Provinces issue agricultural leaflets, which usually deal only with one definite fact, or the description of a single process which it is desirable that the ryot should know or adopt. It is too early yet to judge whether these have been generally successful, but they have been useful in certain cases. Contributions are made to the general vernacular press in certain Provinces with good results.

Agricultural Shows and Exhibitions.—These have been started in nearly every Province. The exhibits are arranged by the Department, one of the members of which attends to lecture on them and arrange practical demonstrations. In some cases advantage is taken of locally arranged non-official exhibitions, and in Bombay, parties of cultivators have been taken to these and the exhibits demonstrated to them. Cattle Shows in some localities have proved a considerable success; the Department gives prizes and organises the show. Local festivals and meetings for the grant of *takavi* advances have been made use of in some cases to demonstrate new implements and other improvements.

Itinerant Assistants.—In most Provinces travelling assistants have been employed for such purposes as the introduction of new varieties of seed and new implements and for advising with

regard to the treatment of special crops, as for instance, in manuring sugar-cane and in pointing out the dangers of over-irrigation with this crop on the Deccan Canals. In the same connection may be mentioned the travelling staff of trained well-borers maintained in the United Provinces. Their operations have been of the greatest value in inclining the people to rely on the assistance of the Department in agricultural matters generally.

Work directly with Cultivators.—In a few cases great improvement in local practice has been obtained by the introduction of cultivators from one district to another. The method is likely to be most useful where a new crop has been introduced into a district, and it is probably capable of extension in such cases.

Short courses for cultivators have been given on the Bombay farms in special matters, such as cotton seed selection. The sons of cultivators are also taken for instruction on these farms. This method is believed to be worthy of more extended trial if cultivators can be induced to go to the farms for the purpose.

In all these methods the aim is to show the actual cultivator some improvement he did not know before and which is within his means. As he is not a capitalist, he cannot usually afford to gamble, but must have a certainty. His cultivation expenses are usually met from borrowed capital and the rates of interest he has to pay are exorbitant. Hence the question of agricultural improvement is closely bound up with the provision of cheap credit, and there must be intimate connection between the Agricultural Department and the co-operative credit organization, which is being developed so extensively.

Apart from all questions of organization, the ultimate work of the Departments is to discover improvements. If any really good improvement can be presented to the Indian agriculturist, he is ready to take it up. That he has not adopted many practices that to the Western eye would seem to be improvements, is often because they are not suited to his own or to India's special conditions, and that would-be reformers have simply been without sufficient knowledge of these. Western ideas and Western

methods cannot be introduced off-hand into India. Much of its agricultural problems have to be worked out on the spot, and there is abundant evidence that these problems are engaging the energies of the Agricultural staff in India in a much more thorough way than ever before. Some of the many directions in which improvements may be looked for were enumerated in the account of the 3rd meeting of the Board referred to above. As these come to fruition, the organization to secure their adoption by the mass of the cultivators will be severely taxed, but I think that the outline just given will indicate that it is likely to prove equal to the demand.